SURGICAL PRACTICE

OF THE

LAHEY CLINIC

BY MEMBERS OF THE STAFF
OF LAHEY CLINIC, BOSTON

781 ILLUSTRATIONS ON 509 FIGURES

W. B. SAUNDERS COMPANY

PHILADELPHIA · LONDON · 1951

Made in the United States of America at the Press of W. B. Saunders Company, Philadelphia.

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PREFACE

This volume of the Surgical Practice of the Lahey Clinic is published almost exactly ten years after the first volume. It presents procedures which by frequent repetition have become quite standardized in this clinic. As stated in the preface of the previous volume, we have continued to be impressed with the fact that, with allowances for the natural variations in anatomy and pathology, the employment of standardized operative procedures by all of the surgeons in the clinic makes for refinement of operative detail and unhesitating cooperation on the part of the operating nurses and assistants. These would seem to be desirable aims from every point of view.

When one realizes that the training of young men in all of the branches of surgery, medicine and anesthesia has now become no small part of the product of this clinic, it is further evident that the standardization and refinement of daily operative procedures make them easier for the young men who come here in fellowship positions to learn and remember them and have them available for use when they go out in practice for themselves. The need for standardization is emphasized when one considers that there are now 110 men in this clinic in fellowship positions in the various branches of medicine, surgery and anesthesiology.

Not only has standardization of procedures and even positions on debatable problems proved valuable to us and our assistants but it has likewise, I am sure, proved valuable to the many visitors and observers who come to the clinic to see operative procedures which are conducted by all the surgeons in the clinic along quite well delineated lines.

With the advent of antibiotics, antithyroid agents, new anesthetic methods and the opening of new fields in all the branches in surgery, many changes in types of surgical procedures will be noted in this volume as compared with the one of ten years ago.

We would like to state that, while we have frequently discussed and emphasized the value of standardizing methods, in presenting these methods and opinions we do not in any way imply that they are the only ones or even that they are the best for everyone. They are what we have found to be the best for us and have the real value of having been arrived at as the result of our own not inconsiderable experiences.

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CONTENTS

THE THYROID GLAND AND NECK

THE ESOPHAGUS, LUNGS AND HEART

THE STOMACH AND DUODENUM

THE SMALL INTESTINE, COLON, SIGMOID AND RECT

THE BILIARY TRACT

THE SPLEEN, ADRENAL GLAND AND PANCREAS

THE BREAST

THE PELVIS

THE BONES AND JOINTS

THE BRAIN, SPINAL CORD AND NERVES

ANESTHESIA

MISCELLANEOUS

THE THYROID GLAND AND NECK

MISCELLANEOUS

THE THYROID GLAND AND NECK

MISCELLANEOUS

THE THYROID GLAND AND NECK

EXPERIENCE WITH THE PREOPERATIVE USE OF THE ANTITHYROID DRUGS

FRANK H. LAHEY AND ELMER C. BARTELS

PHYSIOLOGY OF THE THYROID GLAND

If we understand the fundamentals of the control of thyroid secretion through the so-called pituitary thyroid axis, it becomes much easier to discuss how antithyroid agents act and at what point the thiourea group of drugs, on the one hand, and the sulfon group, on the other, break the chain or cycle of the pituitary thyroid axis.

While the fundamental conception of the origin of hyperthyroidism as residing in the hypothalamus from the supra-optic and paraventricular nuclei stimulating the anterior pituitary to produce a greater amount of thyrotropic hormone is generally accepted, it is by no means a proven fact, and there is at least one clinical state of hyperthyroidism, toxic adenomas, which does not fall satisfactorily within the scope of this explanation.

Certainly, in animals it is possible by the daily administration of an increasing amount of thyrotropic hormone to produce the migration of an increasing number of colloid droplets, the vehicle of thyroxin, from the colloid-filled acini of the thyroid through the acinar epithelial cells ultimately to penetrate the walls of the capillary lining the distal side of the acinar epithelial cells. In microscopic specimens prepared by the technic of de Robertis it is possible to demonstate clearly the progressive penetration into the capillaries of these thyroxin-laden colloid droplets through the acinar cell. As the amount of thyrotropic hormone administered to the animal is increased, progressively increasing numbers of colloid droplets may be seen to migrate from the acinar colloid through the acinar cells and can be seen under the microscope in the process of permeating the walls of the capillaries and emerging in large numbers within the lumen of the capillaries themselves.

The so-called pituitary thyroid axis is the balanced interrelationship between the anterior pituitary with its production of an increased amount of thyrotropic hormone when there is a deficiency in thyroxin and, in turn, the effect of an increased amount of thyroxin on the anterior pituitary when there is too much, thereby depressing the anterior pituitary gland and so diminishing the output of thyrotropic hormone. This is, when there is normal balance, the normal pituitary thyroid axis.

When for some reason at present not clearly known but presumably as a result of stress, strain, undue emotional burdens, shocks and other loads, the stimuli from the hypothalamus increase the activity of the anterior pituitary, this stimulus can, in hyperthyroidism, apparently be of such high degree that the anterior pituitary is not again brought back into balance by the depressing effect upon it in terms of production of an excess of thyroxin. When the pituitary thyroid axis

is thus thrown out of balance there occurs the state known as hyperthyroidism, most typically illustrated in the pure exophthalmic goiter of primary hyperthyroidism.

Why it is that the removal of a large portion, four-fifths to five-sixths, of the hyperplastic thyroid gland present in primary hyperthyroidism breaks this abnormal cycle and restores the pituitary thyroid axis to normal, no one has as yet adequately explained but, as proven by long experience, such is the case. A great many years ago Marine demonstrated that when thyroid hyperplasia was produced experimentally in animals it could be checked only when a large fraction of the gland was removed. This is true in the surgical treatment of hyperthyroidism by subtotal thyroidectomy or any other treatment of the disease, such as with radioactive iodine, which aims at the relief of hyperthyroidism by the destruction or removal of a large fraction of the thyroid gland.

It is to be remembered, as already mentioned, that there is a condition of hyperthyroidism which does not fall readily into this seemingly reasonable way of explaining hyperthyroidism, that is, the state of secondary hyperthyroidism or toxic adenomas. It is in these cases that one not infrequently sees the hyperplasia limited entirely to a single adenoma or to several adenomas, with characteristically firm hyperplastic thyroid tissue entirely within the adenoma, with a large number of acini, with a limited amount of colloid within the acini, and with all the typical symptoms of hyperthyroidism but with the other thyroid tissue in which the adenoma resides entirely nonhyperplastic and normal in character. It is, likewise, in these patients that the removal of the hyperplastic adenoma results in the metabolism being brought completely to normal and the complete clinical relief of all the symptoms of hyperthyroidism. It is in these patients that there exists a weakness in this explanation of the origin of hyperthyroidism by stimuli from the hypothalamus to the anterior pituitary, the production of hyperplasia within the thyroid gland and so the excessive production of thyroxin. That weakness is the fact that although the metabolism is elevated and all the clinical signs of hyperthyroidism seen in patients with pure exophthalmic goiter or primary hyperthyroidism are present, in the patients with toxic adenomas the hyperplasia does not exist in the thyroid gland itself but only in the thyroid tissue within the capsule of the adenoma, and the other thyroid tissue in which the adenoma resides is entirely normal in character. Not only does this hyperplasia which is associated with the hyperthyroidism exist solely in the thyroid tissue within the adenoma, but this fact is further proven by studies, as done by Cope, by measurement of the uptake of radioactive iodine in the normal portion of the thyroid tissue and the increased uptake of radioactive iodine in the hyperplastic tissue within the adenoma. It is in this type of hyperthyroidism that one finds it difficult to explain how the pituitary thyroid axis gets out of balance since it apparently is not affected in this type of secondary hyperthyroidism as in primary hyperthyroidism.

In the patients with secondary hyperthyroidism with hyperfunctioning thyroid tissue entirely within the adenoma, one must assume, then, either that there is an autonomous capacity of the adenoma to incite hyperplasia in the thyroid tissue within the adenoma independent of the pituitary thyroid axis or that the pitui-

tary thyroid axis has the capacity to incite hyperplasia within the adenoma and not in the normal thyroid tissue in which it resides, a less likely explanation.

Production of Thyroxin. With this brief discussion of the manner in which the thyroid gland functions we can likewise briefly discuss the production of thyroxin within the thyroid gland. It has been known for a great many years that the thyroid gland has the greatest affinity for iodine of any structure in the body and that within the thyroid gland iodine exists in the form of an iodide. The synthesis of thyroxin consists, as a first step, of the combining of free iodine with tyrosine to form diiodotyrosine. Since iodine exists in the thyroid gland not as free iodine but in the form of an iodide, there must exist within the thyroid a process which liberates the iodine from its iodide combination into the form of free iodine, and this exists in the acinar cell as an enzymatic process called the peroxidase process. It is upon this process that the thiourea group of antithyroid agents apparently acts, as proven by the fact that with the administration of propylthiouracil or tapazole or any other agent of the thiourea group, the stage of synthesis of thyroxin represented by the production of diiodotyrosine does not exist. In patients who have been saturated with the thiourea group of agents, no diiodotyrosine will be found in the colloid within the acini, proving that the block occurred prior to this stage of synthesis. On the other hand, when the other antithyroid agents which are known to inhibit the synthesis of thyroxin, such as sulfathiazole or others of the sulfon group, are employed, the synthesis of thyroxin will be completely interrupted, but interrupted at the point where diiodotyrosine will be found in the colloid within the thyroid acini. Beyond that stage of the development of thyroxin, that is, the formation of diiodotyrosine, however, there is, by the administration of the sulfon group of drugs, brought about a block in the synthesis of thyroxin, and none of this material is produced.

It may readily be seen from the above, then, that the administration of the antithyroid agents of the thiourea group blocks the synthesis of thyroxin by failing to make available one of the necessary factors for the production of thyroxin, that is, free iodine, while the effect of lowering metabolism and interfering with the synthesis of thyroxin following the administration of the sulfon group of drugs results in a block beyond the stage of the production of diiodotyrosine and between that and the final synthesis of diiodotyrosine into thyroxin.

ACTION OF THE ANTITHYROID DRUGS

A new era in thyroid surgery for hyperthyroid patients began with the introduction of the antithyroid drugs in 1943. Since then we have used these agents extensively in the preoperative preparation of patients with hyperthyroidism, having prepared for subtotal thyroidectomy 2200 patients with hyperthyroidism up to the present time. The usefulness of these agents was quickly established when it was found that when one of these substances was properly administered to a patient with hyperthyroidism, irrespective of the severity of the disease short of a morbid state with irreversible changes, the patient could be restored to an euthyroid state allowing thyroidectomy with a surgical risk comparable with that of simple nontoxic adenoma. The use of Lugol's solution alone preoperatively was quickly outmoded since, although highly beneficial in cases of mild

primary hyperthyroidism, permitting safe thyroidectomy, it fell far short of satisfactorily improving patients with severe degrees of hyperthyroidism, especially those with long-standing disease and those classified as having thyrocardiac disease. It is now our practice to treat all patients with hyperthyroidism preoperatively with the antithyroid drugs except those with the mildest degree of the disease in whom the basal metabolic rate is brought to normal by iodinization. Our experience to date (seven years), has borne out the early prediction of the value of these drugs since they fill an essential need in the successful preoperative management of the hyperthyroid patient.

It has been satisfactorily established that these drugs block the manufacture of thyroid hormone and act directly on the enzyme system in the thyroid which has as its function the conversion of inorganic iodide to the organic form. Since the thyroid hormone already manufactured is not affected, the effect subjectively of an antithyroid drug will not become apparent and the basal metabolic rate will not be decreased until this store has been exhausted. This explains the slowness in the fall of the basal metabolic rate in the hyperthyroid patient who has a large adenomatous goiter or in the patient who previously received iodine which resulted in the manufacture of a large store of organic iodine. Therefore, knowledge of previous administration of iodine is necessary in predicting the recovery rate of a given hyperthyroid patient. From our experience in treating a large number of patients with hyperthyroidism, many of whom had complicating coexisting disease, it can be said that in no instance were we unsuccessful in lowering the basal metabolic rate and creating an euthyroid state when the antithyroid drug was given in a sufficiently large dose over an adequate length of time. In some patients, especially those with large goiters, particularly adenomatous goiters, who had previously received iodine, many months (as long as one year) were required to accomplish the desired result.

So specific is the action of these agents that the following principle seems justified: if a patient suspected of having hyperthyroidism fails to show discernible subjective and objective improvement on a known effective dose of a given antithyroid drug after three to four weeks of treatment, the diagnosis of hyperthyroidism is open to doubt and some other cause of the patient's symptoms should be considered. This principle is very helpful in analyzing those patients who are sent to us with a question of hyperthyroidism and who have received antithyroid treatment; failure to become symptom-free after one to two months of active treatment rules out hyperthyroidism. A second feature of the principle deals with the development of myxedema. Patients with primary hyperthyroidism can be overtreated to the point of developing myxedema, so sensitive are they to the antithyroid drugs. This is not true of the patient with a normal thyroid gland or one who has an adenomatous goiter with hyperthyroidism. For example, a patient suspected of having primary hyperthyroidism who is given a potent dose (300 mg. daily) of propylthiouracil for two to three months without substantial clinical improvement or the development of myxedema cannot have hyperthyroidism. If a patient with mild primary hyperthyroidism were treated for two months with such a dose obvious myxedema would certainly develop. Because of this principle these drugs may be used as diagnostic agents in occasional cases.

Failure of an elevated basal metabolic rate to return to normal in spite of energetic antithyroid treatment in patients who have hyperthyroidism can be explained on the basis of coexisting disease. That is, if the metabolic rate is truly basal, and there is decrease of the rate but failure to become normal, one must consider the presence of coarctation of the aorta, acromegaly or some cause other than hyperthyroidism for the hypermetabolism. We have seen cases of both coarctation of the aorta and acromegaly in which this occurred. In Figure 1 is

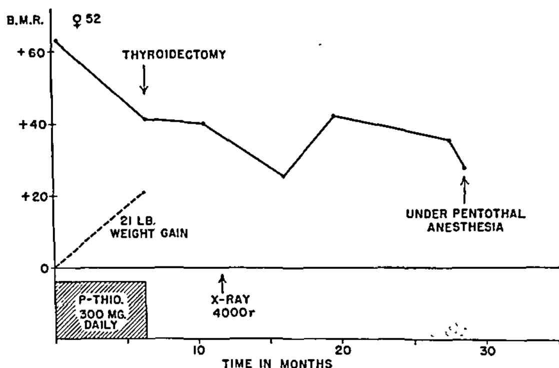


Fig. 1. Patient had acromegaly and hyperthyroidism. Long continued antithyroid treatment failed to restore the basal metabolic rate to normal. After subtotal thyroidectomy the rate still *remained above normal even when taken under anesthesia, indicating nonthyroid hypermetabolism.*

shown the experience with a case of acromegaly with complicating adenomatous goiter and hyperthyroidism. The basal metabolic rate after six and a half months of administration of propylthiouracil fell from +63 to +41. There was a gain in weight of 21 pounds and marked evidence of subjective and objective improvement. Subtotal thyroidectomy was done, following which the basal metabolic rate remained elevated, indicating the presence of nonthyroid hypermetabolism. Roentgen therapy to the pituitary resulted in a transient fall in the basal metabolic rate but it again rose to the preoperative level. The basal metabolic rate under anesthesia was above normal, +29, indicating true hypermetabolism.

RATE OF RESPONSE TO THERAPY

Continued experience has not altered our early observations that the rate of response of a given hyperthyroid patient to antithyroid treatment can be predicted fairly accurately. Essential to such a prediction is first, the knowledge of the type of hyperthyroidism, whether it is primary hyperthyroidism (exophthal-

mic goiter, diffuse goiter) or adenomatous goiter, and second, information as to previous administration of iodine. In cases of primary hyperthyroidism (Fig. 2), one day of treatment is required for each percentage point of elevation of the basal metabolic rate and in cases of adenomatous goiters one day of treatment is necessary for each 0.5 per cent elevation (Fig. 3). If iodine has been admin-

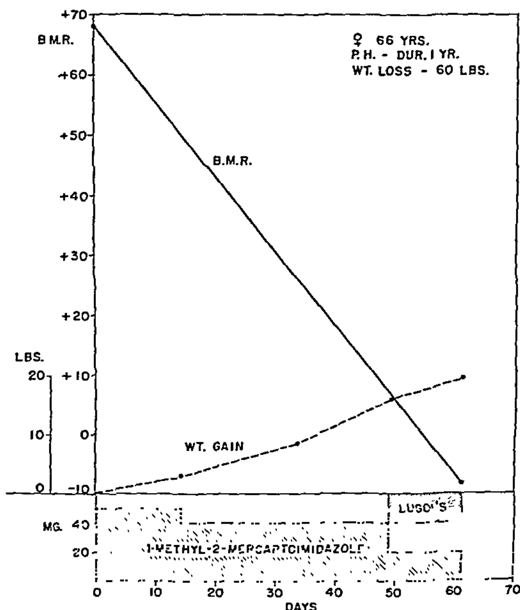


Fig. 2. This patient with severe primary hyperthyroidism had a decrease in the basal metabolic rate of 62 points in 76 days, weight gain of 19 pounds and loss of all signs and symptoms of hyperthyroidism. An average of approximately 40 mg. a day of tapazole was given.

istered previously, the response is slower, particularly in the patients with adenomatous goiter. The size of the gland is also a factor which must be considered in calculating the expected response to treatment. Individualization must, of course, be a feature of antithyroid therapy since the factors of age, duration of hyperthyroidism, degree of visceral depletion and nature of coexisting disease must all be given careful consideration.

The readiness for thyroidectomy is not determined solely by a normal basal

metabolic rate since this is only one factor indicating recovery. The patient must be restored to a state of health commensurate with age and coexisting disease. All symptoms of hyperthyroidism should be relieved and widespread visceral strain and depletion resulting from hyperthyroidism should be compensated. Patients with cardiac complications must be given long periods of preoperative treatment, as should patients with associated diabetes or psychotic states. The

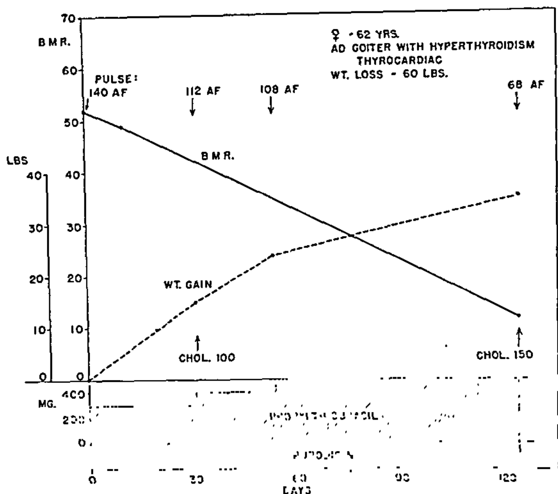


Fig. 3. This patient, a thyrocardiac with rapid auricular fibrillation, had hyperthyroidism due to a large adenomatous goiter. The basal metabolic rate fell slowly, reaching normal after 130 days of large daily doses of propylthiouracil. Note the normal cholesterol value, a prerequisite to thyroidectomy, at end of treatment. The patient gained 35 pounds and the pulse rate fell from 140 to 68.

existing complications are greatly improved if the patient is maintained in an euthyroid state for a prolonged period.

The basal metabolic rate must be normal at the time of thyroidectomy if the anesthesia course is to be normal (pulse below 100) and the postoperative course uneventful. At times patients are seen who have had long periods of antithyroid treatment which should be sufficient to restore the metabolic rate to normal but, when tested, the rate is still elevated (Fig. 4). The sustained hypermetabolism could be dismissed as being the result of inaccuracy of the test or failure of the patient to take the test easily. Both of these opinions may be wrong and such a patient would undergo thyroidectomy in a state of true hyperthyroidism which could lead to a toxic anesthesia course and danger of a serious postoperative

pears to be little choice between propylthiouracil and 1-methyl,2-mercaptoimidazole since they are both effective agents and the incidence of reactions is extremely low. It is advisable to have sufficient experience with more than one antithyroid drug so that another drug may be given in the event of a reaction to the initial drug. This we have successfully done in a number of cases.

In administering an antithyroid drug it is advisable to continue a full daily effective dose until an euthyroid state is reached. A common error is to discontinue treatment or reduce the dose to a level which is ineffective because of the development of a symptom unrelated to the drug or to assume wrongly that the lower the dose the less the chance of a drug reaction. Headache, nausea and vomiting, diarrhea, dizziness, slight sore throat and increasing hyperthyroid symptoms which occasionally occur early in treatment (first week) are not indications of drug sensitivity. In our experience, only fever, real granulocytopenia, sore throat with granulocytopenia, skin eruption and hives, and swollen salivary glands indicate drug sensitivity requiring discontinuance of treatment. The reactions are specific so that after all signs and symptoms have been relieved, a small test dose of the drug in question will cause a prompt return of the evidence of sensitivity.

Lugol's solution is indicated only for patients with primary hyperthyroidism. In cases of severe primary hyperthyroidism with impending crisis, Lugol's solution, along with the antithyroid agent, should be given initially for six days for its antithyroid effect. The antithyroid drugs are so slow acting that they have no value in treating patients in thyroid storm. Usually, however, Lugol's solution is given only for its involuting effect and is administered with the antithyroid drug preoperatively during the last three weeks of treatment. A dose of 10 drops daily is sufficient to produce an adequate state of involution of the thyroid gland. Lugol's solution must not be given continuously with the antithyroid agent since a blocking effect might occur in patients with large goiters, preventing the lowering of the basal metabolic rate and relief of hyperthyroidism. We observed this blocking effect in 3 young girls who had large hyperplastic goiters. Response occurred when the iodine was withdrawn.

Overtreatment with the antithyroid drugs, leading to myxedema, should be avoided. This, however, has never been observed to occur in patients with adenomatous goiter in spite of many months of active antithyroid treatment. The physician must be especially watchful for the development of myxedema in cases of primary hyperthyroidism. Since the symptoms and objective signs of myxedema are slow to develop and since the basal metabolic rate (a rough test) may not reflect the true metabolic state, the plasma cholesterol level is of great value. Therefore, when prolonged antithyroid treatment is necessary, the plasma cholesterol value (Fig. 3) should be determined periodically. A sharp rise indicates developing myxedema and calls for slackening of treatment. The dangers involved in undertaking thyroidectomy in the presence of myxedema are real and have been repeatedly emphasized.

Overtreatment must also be carefully avoided in treating patients with hyperthyroidism who are pregnant for fear of disturbing the pregnancy. That antithyroid treatment is safe during the first two trimesters of pregnancy has been indicated by our experience with 25 such cases. After preparation with one of

the thiouracil drugs and iodine, subtotal thyroidectomy was safely done in all cases. The pregnancies in these 25 patients resulted in 20 normal children, one set of twins, 2 stillbirths, and 3 premature deliveries at eight months and one spontaneous abortion at 5 months, a fetal loss of 24 per cent. It is strongly believed that if special attention is taken after thyroidectomy to prevent hypothyroidism, which may harmfully affect the fetus, the infant loss will be greatly lessened. Therefore, after the thyroidectomy, administration of desiccated thyroid (½ grain) and Lugol's solution (5 drops) daily until termination of pregnancy is suggested. In the last 7 patients so treated after thyroidectomy there has been a fetal loss of one, or 14 per cent, this being due to intra-uterine asphyxia, as compared to 28 per cent in those not so treated.

The essentials of the proper preoperative use of the antithyroid drugs (Table 1) must be strictly adhered to if patients with hyperthyroidism are to undergo

Table 1. Essentials of Proper Preoperative Use of Antithyroid Drugs

1. Distinction between types of hyperthyroidism
   a. Primary hyperthyroidism
   b. Adenomatous goiter with hyperthyroidism
2. Choice of antithyroid drug
   a. Proper daily dose
   b. Awareness of specific reactions with indications for shifting to another antithyroid drug
3. Duration of therapy (carefully individualized)
   a. Continue until euthyroid state is attained
   b. [illegible]—at times available
4. [illegible]
   [illegible]
   b. Involutional effect
5. Avoidance of overtreatment (myxedema)

thyroid surgery in the best possible condition, thereby assuring satisfactory anesthesia, postoperative course and ultimate recovery. These principles have been followed with satisfactory results, as indicated by the low operative mortality in 2200 patients so managed. These 2200 patients include many severely ill patients who might not have been offered thyroidectomy in the days before the antithyroid drugs were available. Irrespective of the severity of the hyperthyroidism or seriousness of complications, except fatal malignant or cardiovascular disease, no patient is refused thyroidectomy. In the entire group there were 5 deaths, a mortality of 0.22 per cent. All of the patients who died had thyrocardiac disease.

Proper surgical and anesthesia technics which will lead to a successful thyroidectomy in these thyrocardiac cases have been emphasized many times by us in the past. To these technics should be added the procedure of so-called prophylactic tracheotomy in these thyrocardiac cases. In the past, tracheotomy was done at the time of the thyroidectomy when it was thought the airway was inadequate because of previous tracheal compression or deviation or when cord paralysis was present. Tracheotomy was also done postoperatively when the airway became inadequate as a result of laryngeal edema or nerve paralysis occurring at the time of thyroidectomy. It is now our practice to do a tracheotomy at the time of thyroidectomy in those patients with low cardiac reserve in whom

it is feared that even a minor degree of anoxemia would be harmful, this in the absence of tracheal deviation or laryngeal disease. A tracheotomy done at the time of the thyroidectomy is a relatively easy procedure, it does not increase the postoperative morbidity and increases the hospital stay only by a few days. We are certain this procedure has been life-saving in some of our seriously ill cardiac patients.

After operation, neither the antithyroid agents nor iodine is given since if these agents are properly administered preoperatively, they could serve no useful purpose postoperatively.

SUMMARY

When preoperative antithyroid treatment is carefully administered, patients with hyperthyroidism, irrespective of their initial clinical state, can undergo thyroidectomy with complete safety if careful operative and anesthesia technics are followed. Prophylactic tracheotomy in patients with cardiac complications is advisable as an additional means of preventing postoperative morbidity and mortality.

THE ROLE OF THE ANESTHESIOLOGIST IN THE MANAGEMENT OF THYROID PATIENTS

URBAN H. EVERSOLE

The management of patients with thyroid disease is the joint responsibility of the internist, surgeon and anesthesiologist.

Hyperthyroidism, while essentially a disease associated with abnormal function of the thyroid gland, is a systemic disease affecting practically every system in the body. The symptoms presented by patients with hyperthyroidism are evidences of the general nature of the disease. The complaints are usually nervousness, emotional instability, irritability, weight loss, weakness, increased appetite, intolerance to heat, dyspnea, palpitation and in severe cases sometimes even vomiting and diarrhea.

PREOPERATIVE PREPARATION OF PATIENT

The preoperative preparation of these patients from the medical standpoint is directed toward the correction of these complaints. With rest, sedation, proper diet high in carbohydrates and with adequate protein and vitamin content, plus the proper medication, improvement will result and most or all of these symptoms disappear.

Prior to the introduction of the so-called antithyroid drugs it was thought necessary to prepare all patients with hyperthyroidism for surgery in the hospital or at least on bed rest. However, since the introduction of these drugs most of these patients can be prepared adequately and at the same time remain ambulatory. The introduction of propylthiouracil and allied drugs for the treatment of hyperthyroidism has in many ways almost revolutionized the preparation of these patients for surgery. Lahey, Bartels, Warren and Meissner[3] have pointed out that the drug should be administered until its maximum benefit has been obtained. They have called attention to the fact that although the secondary symptoms of hyperthyroidism may completely disappear and the patient may be transformed from a wildly excited and emotionally unstable, seriously ill person to one who has lost most of the classical symptoms of hyperthyroidism, since there is no involution of the thyroid gland this drug should not be considered as a substitute for surgery. Since the introduction of propylthiouracil in the management of thyrotoxicosis there has been a steady decrease in the number of multiple stage operations performed. This has been accomplished with a decrease in the mortality rate. In 1942, 10 per cent of patients operated on at the Lahey Clinic for hyperthyroidism had multiple stage operations. In the first half of 1943, this percentage was 12. A few selected patients were given thiouracil in the latter half of 1943. The percentage during the last six months of 1943 was 8. The percentage of multiple stage operations has continued to decrease from 5

Originally published in Surgical Clinics of North America, 30 673–685 (June) 1950.

per cent in 1944, 1 per cent in 1945, until at the present time no multiple stage operations are being performed.

The remission of toxic symptoms and decrease in metabolic rate are of clinical significance to the anesthesiologist, with reference to his selection of the preoperative medication and postoperative narcotics and sedation. If the same dose of opiate or barbiturate is given to patients prepared with propylthiouracil as was previously given to those prepared with iodine alone, serious respiratory depression occasionally may result.

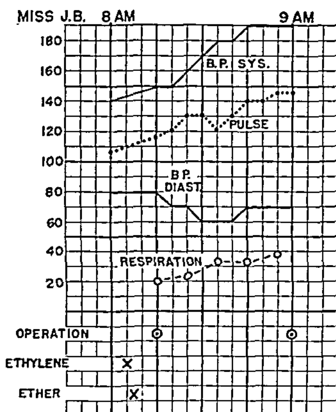


Fig. 6. Typical chart of the anesthetic course of a patient with hyperthyroidism prepared with iodine, during which it was decided wise to terminate the operation after the removal of one lobe of the thyroid gland. Note the rising pulse and systolic blood pressure and the increase in pulse pressure. (From Transactions of the American Association for the Study of Goiter, 1946.)

With the increasing use of propylthiouracil and allied drugs in the preoperative preparation of patients with hyperthyroidism, indications for terminating the operation short of subtotal thyroidectomy rarely occur. The anesthesiologist, however, should be ever aware of these well-known warnings. In addition to the grave prognostic signs of advanced years, duration of the disease for over one year, loss of over 20 per cent of body weight and failure to gain weight while under treatment, and a persistently rapid pulse, certain signs may develop during the course of the anesthesia which should be taken as warning signs, and the division of the operation into more than one stage probably is advisable. These signs are increased oxygen consumption, failure of the preoperative medication to elicit the expected effect, rapid pulse (over 120) prior to the induction of anesthesia which persists, rise in the pulse rate under anesthesia to over 120, rise in the systolic blood pressure or a significant increase in pulse pressure.

Figure 6 is an anesthesia chart of a patient, prepared with iodine alone, who showed evidence of toxicity during the course of the operation sufficient to warrant stopping the surgical procedure when one lobe had been removed. Figure 7 is a typical anesthesia chart of a patient prepared with propylthiouracil.

There is one group of patients with hyperthyroidism in which the seriousness of the risk is not so generally appreciated. These are patients who suffer from the apathetic type of hyperthyroidism.[2] They are usually elderly individuals who have had the disease for a long time, and who might be described as depleted

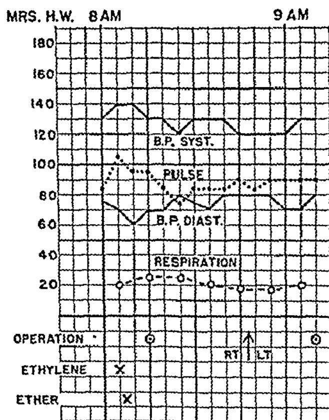


Fig. 7. Typical chart of the anesthetic course of a patient with hyperthyroidism prepared with propylthiouracil. Note pulse rate (usually below 100) and lack of rise in systolic blood pressure or increase in pulse pressure. (From Transactions of the American Association for the Study of Goiter, 1946.)

and unable to manifest the signs of thyroid toxicity. They frequently show no increase in pulse rate, and the basal metabolic rate may be near normal. There is, however, usually evidence of considerable weight loss. These patients react poorly to large doses of sedatives. In the preoperative preparation period every effort should be made to build these patients up by rest, sedation and high caloric diet, plus antithyroid medication.

The two most important factors with reference to thyroid disease from the standpoint of the anesthesiologist are: (1) whether the patient is toxic and if so if he has been prepared with iodine or with thiouracil, and (2) factors which may cause mechanical interference with respiratory exchange, such as thyroiditis, large or intrathoracic goiters and carcinoma of the thyroid. Secondary operations on the thyroid gland may be technically difficult and hence are more likely to produce respiratory obstruction.

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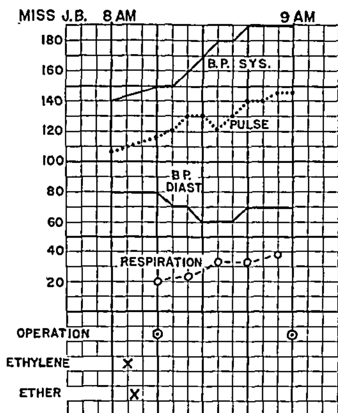


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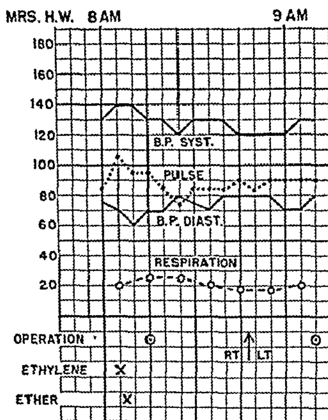


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Patients with thyroid disease, in common with all surgical patients, should be visited preoperatively by the anesthesiologist. This preanesthetic visit is quite important. Many times patients will say that they have no fear of the operation—it is only the anesthetic that they fear. A preoperative visit can be very valuable in allaying this fear and in gaining the patient's confidence. In addition, the anesthesiologist, by a careful study of the history, physical findings, laboratory data and preoperative course, can better evaluate the physical state of the patient. He gains an appreciation of the entire problem and a sound basis for the selection of the anesthetic agent and method as well as the preoperative medication.

In our scheme of thyroid management there is no place for the so-called "sneak operation." While it is recognized that thyrotoxicosis oftentimes results in emotional instability with extreme nervousness and irritability, a frank presentation to the patient of the facts concerning the disease and a discussion of the outlook and the necessity for surgical intervention, rather than disturbing the patient, may have just the opposite effect. Most patients prefer to face the problem and to know when the operation is to be performed rather than to live each day in a state of uncertainty.

ANESTHESIA

General anesthesia is selected for all thyroid operations. This affords comfort for the patient for the wide lateral exposure so essential for the anatomical removal of a large part of the thyroid gland without injury to the parathyroid glands or to the recurrent laryngeal nerves. The carbon dioxide absorption technic is employed and an endotracheal tube is inserted if indicated. Oftentimes too much stress is placed upon the selection of the anesthetic agent and not enough on fundamental principles, such as the maintenance of an adequate airway, and the avoidance of even brief intervals of anoxia.

Nitrous oxide and ethylene are both weak anesthetic agents and neither of them can be depended upon to provide satisfactory surgical anesthesia without danger of anoxia. On the other hand, sufficient oxygen can be administered with both of these agents if they are supplemented with ether or with cyclopropane. Cyclopropane is a potent anesthetic agent and unsupplemented will allow for sufficient oxygen to obviate any danger of anoxia. In addition, this agent has the advantage of rapidity of action and patients usually find it pleasant to take. Cyclopropane, on the other hand, has certain inherent dangers. It has been very well established experimentally that cardiac irregularities may arise spontaneously under cyclopropane anesthesia[4, 8] even with adequate oxygenation. Orth, Lee and Meek[5] have shown that these irregularities are not of anoxemic origin since the hemoglobin was shown to be approximately saturated with oxygen. Furthermore, Orth, Wangeman and Meek[6] reported that barbiturates do not give constant protection from these irregularities. That the administration of epinephrine[7] in doses sufficiently small as to cause no cardiac irregularities in unanesthetized dogs produces frequent cardiac irregularities and occasionally ventricular fibrillation, and death in dogs under cyclopropane anesthesia is well known. In view of this experimental evidence as well as considerable clinical evidence[1, 9] of the danger of cyclopropane to patients with thyrotoxicosis, a disease known to cause hyperirritability of the heart, it would seem unwise to use cyclopropane anesthesia

for operations for hyperthyroidism. Since the patient prepared with antithyroid drugs is so frequently euthyroid and apparently free from all of the usual symptoms of hyperthyroidism, the necessity for refraining from the use of cyclopropane might be questioned. On the other hand, it is sometimes difficult to determine in every instance whether all the effects of increased thyroid activity have completely disappeared. Furthermore, at the present time it would seem an unwarranted conclusion to say that the disappearance of clinical symptoms of hyperthyroidism were of necessity accompanied by complete disappearance of increased irritability of the heart. It is a common clinical experience that when cardiac irregularities develop under cyclopropane anesthesia, as they not infrequently do in patients without any question of cardiac irritability, they can often be eliminated by decreasing the concentration of the cyclopropane in the mixture and adding ether as necessary to maintain anesthesia.

Tribromethanol (avertin) may be used as a basal anesthetic for thyroid operations. It has certain undesirable features, however. In order to obtain the maximum effect from this agent it should be administered from twenty to forty minutes prior to induction of anesthesia and the anesthesiologist should be attendant on the patient during this entire time because of the danger of respiratory obstruction. Furthermore, respiratory depression may persist for a considerable length of time and the patient may require additional nursing care following the operation. The effect of a given dose of tribromethanol is often unpredictable and it is a frequent observation that, contrary to expectations, the pulse rate in thyrotoxic patients may increase rather than decrease under avertin narcosis. This agent is, however, very useful as a basal anesthetic for children with hyperthyroidism.

Pentothal sodium is a valuable agent for induction for patients who are nervous. Extreme care should be taken to prevent laryngeal spasm and respiratory obstruction. If the throat is carefully sprayed with 10 per cent cocaine prior to the administration of the pentothal, laryngospasm is not likely to occur. After the patient is unconscious, anesthesia may be carried on with ethylene or nitrous oxide and ether. We do not use pentothal as the sole anesthetic agent for thyroid surgery.

Adequate medical preparation of the patient, the preanesthetic visit by the anesthesiologist, with a careful consideration of the patient's physical state, selection of the proper anesthetic agent and method, all tend to decrease the number of operative as well as postoperative complications. In spite of this careful routine, a certain number of complications may occasionally arise, during the course of thyroid surgery as well as postoperatively, with which the anesthesiologist should be prepared to cope. Obviously, the ideal handling of any complication is its anticipation and the taking of measures for its prevention.

COMPLICATIONS AND THEIR MANAGEMENT

Respiratory Obstruction at Operation. Varying degrees of respiratory obstruction may accompany thyroid surgery. Thyroiditis and large adenomatous goiters, particularly with intrathoracic extension, may so deviate or compress the trachea as to interfere seriously with respiratory exchange. Carcinoma of the thyroid gland may also deviate or compress the trachea by virtue of the size of

the tumor. In addition, carcinoma of the thyroid may directly invade the tracheal wall. Paralysis of one or more vocal cords may seriously interfere with the airway. Roentgenograms of the neck should be taken if any tracheal abnormality is suspected.

In addition to these factors which exist preoperatively and whose presence should be known to the anesthesiologist before he induces anesthesia, surgical manipulation incident to the removal of the thyroid gland may result in varying degrees of respiratory obstruction. This is particularly true with malignant disease and with secondary operations. Endotracheal anesthesia should be used for thyroid surgery in all instances where there is a deviated or compressed



Fig. 8. Eyes of patient with severe exophthalmos protected by a thin sheet of gutta-percha which is fused to the skin by pressing with a gauze sponge soaked in hot water. An inert ointment is placed in the eyes before covering with gutta-percha. (From Transactions of the American Association for the Study of Goiter, 1946.)

trachea, cancer of the thyroid, intrathoracic extension of the tumor, paralysis of either or both vocal cords and for all secondary operations. Furthermore, should respiratory difficulties occur during the course of an operation there should be no hesitancy about the introduction of an endotracheal tube during the course of the operation if the ordinary methods, such as insertion of oral or nasal airways, forcible extension of the chin and positive pressure on the breathing bag, fail to relieve the obstruction completely. If there is sufficient distortion of the anatomy in the region of the trachea and recurrent laryngeal nerves, persistent preoperative stridor may be present. When this is true, it is advisable to place the endotracheal tube in position under topical anesthesia before a general anesthetic is administered. These patients are on the brink of respiratory obstruction all of the time and the depression which may follow preoperative medication plus the irritation of the anesthetic agent may be sufficient to cause complete respiratory obstruction and serious anoxia The introduction of an endotracheal tube under topical anesthesia is not a difficult procedure, and neither is it a

very trying one for the patient. Considerable pains should be taken to explain the reason for the procedure to the patient and to instruct him to breathe quietly after the tube is in place and to make no effort to talk. The pharynx, larynx and trachea are carefully sprayed with a topical anesthetic, such as 10 per cent cocaine, prior to the introduction of the tube. Manipulations in the mouth incident to the introduction of an endotracheal tube while the patient is awake should be especially gentle.

Trauma to Eyes. Sometimes the eyelids of patients with severe exophthalmos are not completely closed even under anesthesia. This may result in trauma to the eye or there may be sufficient drying of the cornea to cause damage. If an inert ointment is placed in the eyes and they are covered with a thin sheet of

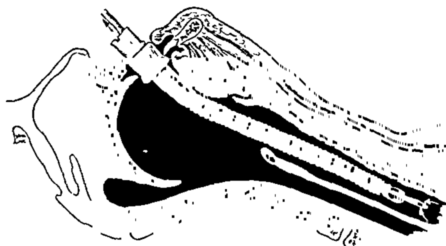


Fig. 9. Aspirating catheter passed [illegible] the opera- [illegible] an Associa-

gutta-percha which can be fused to the skin with a piece of gauze dipped in hot water, adequate protection from injury is afforded (Fig. 8).

Hemorrhage. Hemorrhage, while primarily a surgical complication, is a factor to be considered by the anesthesiologist. If bleeding seems to be excessive, steps should be taken to combat the inevitable blood pressure fall, such as the intravenous administration of fluids or blood as indicated.

Excess Mucus. Excess mucus can be very troublesome during the course of an operation and it may be necessary to remove it by aspiration. When an endotracheal tube is in place, an aspirating catheter can be passed through the tube for the removal of mucus. Any excess mucus present at the close of operation should be removed by aspiration before the patient is returned to his room. Figures 9 and 10 demonstrate the method of removing the endotracheal tube at the close of operation so as to remove the excess mucus which may have accumulated in the trachea. Postoperatively, mucus may constitute a real problem since it may accumulate in quantities sufficient to obstruct a bronchus or bronchioles, with atelectasis distal to the plug, and the unfortunate chain of events which can follow such an episode if the condition is not relieved. Drugs used postoperatively for restlessness and to relieve pain have a tendency to depress the cough reflex and contribute to the accumulation of mucus. These patients should be

turned frequently and urged to cough. If the patient demonstrates his inability or unwillingness to raise secretions that have accumulated in the tracheobronchial tree, these should be removed by aspiration. This can usually be accomplished by passing into the trachea a number 20 or 22 urethral catheter to which suction is applied. If this catheter is passed blindly through one nostril, many times it will pass directly into the trachea. If this does not happen, it can be guided in under direct vision through a laryngoscope. Preliminary spraying of the throat with 10 per cent cocaine makes this procedure less uncomfortable for the pa-

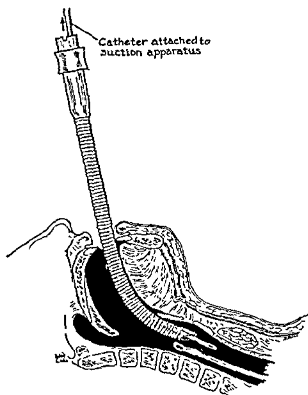


FIG. 10. The aspirating catheter is left in place as the endotracheal tube is removed to remove secretions in the upper part of the trachea and pharynx. (From Transactions of the American Association for the Study of Goiter, 1946.)

tient. Figure 11 shows the method of guiding the catheter into the trachea under direct vision for the aspiration of mucus. Usually this catheter method for the removal of secretions is sufficient. However, if the secretions have formed a plug in a bronchus or bronchioles sufficient to cause atelectasis of one or more lobes, it is better to remove the secretions by a more accurate method. This can be done by passing a bronchoscope and removing the secretions under direct vision.

Hole in the Trachea. This is a rare occurrence at operation. The surgeon should immediately inform the anesthesiologist should such an accident occur. The use of positive pressure by squeezing the breathing bag on the anesthetic machine will prevent the aspiration of blood through the opening in the trachea while it is being closed.

Carotid Sinus Syndrome. A very infrequent but alarming complication which may occur during operations in the neck is a carotid sinus syndrome. This is due to stimulation of a hypersensitive carotid sinus and it is particularly prone to occur when the carotid artery is retracted laterally. The symptoms are a sud-

den severe drop in blood pressure accompanied by a marked slowing of the pulse, even to asystole. There may be a sharp decrease in the respiratory rate and amplitude, but this is by no means constant. Successful treatment depends on early recognition with immediate removal of the stimulus, artificial respiration, and lowering of the patient's head as a safeguard againest cerebral hypoxia. The injection of 5 to 10 cc. of 1 per cent procaine around the bifurcation of the carotid artery should immediately be carried out to block efferent impulses from the carotid sinus. Atropine sulfate (1/100 to 1/150 grain) may be helpful in depressing the vagal component of this syndrome. The recovery is usually very

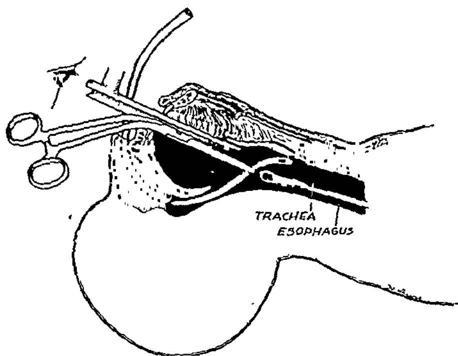


Fig. 11. Aspirating catheter being guided into the trachea with forceps under direct vision. (From Transactions of the American Association for the Study of Goiter, 1946.)

dramatic. Figure 12 is an anesthetic chart showing the effect of a carotid sinus syndrome occurring during the course of an operation on the thyroid gland.

Convulsions. Convulsions under anesthesia constitute another rare but grave complication. The mortality rate of convulsions under anesthesia has been reported as high as 75 per cent. Of the 5 convulsions under anesthesia that have occurred at this clinic, 2 occurred in patients with hyperthyroidism. Both of these cases terminated fatally. The administration of a barbiturate, such as pentothal sodium intravenously, will usually stop the convulsions. This, of course, must be administered very cautiously since the patient is already under a general anesthetic. The establishment of a patent airway is imperative and adequate oxygenation must be insured, using artificial respiration if necessary. It might be wise to administer intravenous calcium gluconate against the possibility of tetany. Obviously, the anesthetic should be discontinued and only oxygen administered. The soda lime should be changed to insure adequate removal of carbon dioxide and the valves of the machine checked to be sure the exhaled gases are passing through the soda lime. Glucose and saline solution should be administered intravenously.

Postoperative Respiratory Obstruction. Progressive respiratory obstruction is not an unusual complication following thyroidectomy. Serious respiratory obstruction may occur as a result of hemorrhage. If the bleeding is arterial and beneath the prethyroid muscles, the pressure on the trachea may approach the systolic blood pressure in magnitude. To relieve this obstruction it is necessary to open the operative wound and remove the clot, thus releasing the pressure on the trachea. These episodes may sometimes be quite dramatic and it may

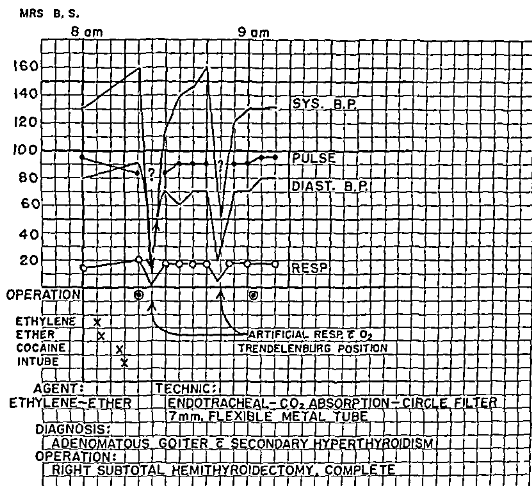


Fig. 12. Anesthetic chart of a patient developing carotid sinus syndrome during the course of thyroidectomy. Note rapid onset of symptoms, with just as rapid recovery after removal of inciting stimulus.

be necessary to open the wound rapidly in the ward without the usual aseptic precautions. There is usually time, however, to insert an endotracheal tube under topical anesthesia and bring the patient to the operating room before opening the wound.

Obstruction may be due to bilateral paralysis of the vocal cords or to edema of the false vocal cords and occasionally there is sufficient pharyngeal edema to cause respiratory obstruction. This edema may be caused by the irritation of an oral airway or endotracheal tube, and as the partial obstruction causes further irritation a vicious cycle is established. At first there may be only a mild stridor but this may progress to complete respiratory obstruction. Paralysis of the vocal cords, if present, may be and usually is temporary. If the patient shows evidence of progressive obstruction and particularly if an examination reveals an inade-

quate glottic opening, tracheotomy should be performed. This operation may be done deliberately without danger or discomfort to the patient if the throat

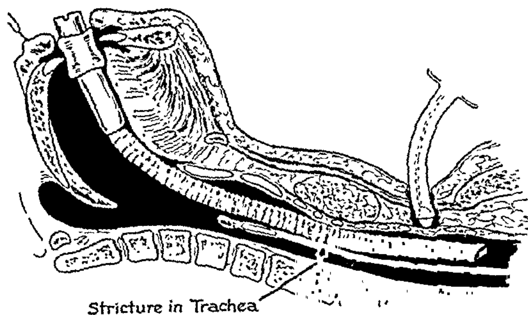


Fig. 13. Endotracheal tube in trachea extending below tracheotomy opening. (From Transactions of the American Association for the Study of Goiter, 1946.)

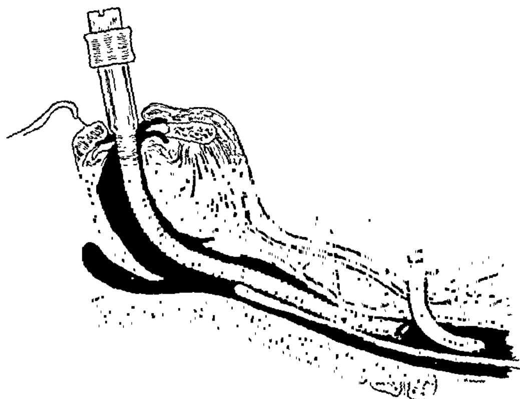


Fig. 14. Endotracheal tube withdrawn just far enough to permit the introduction of a tracheotomy tube. If obturator is left in place in the tracheotomy tube, the patient will continue to breathe through the endotracheal tube for maintenance of anesthesia. (From Transactions of the American Association for the Study of Goiter, 1946.)

is sprayed with cocaine solution and an endotracheal tube inserted between the vocal cords prior to the administration of the general anesthetic. These patients

are all dangerously near to complete respiratory obstruction. Even the introduction of cocaine into the throat may be a strong enough irritant to cause complete obstruction. For this reason no attempt to cocainize the throat or to introduce an endotracheal tube should be made until the operating team is ready to proceed. The operative field should be prepared and the patient draped for surgery before the anesthetic is started. These precautions are observed in order to allow for an immediate tracheotomy should complete respiratory obstruction ensue. The endotracheal tube is left in place until the opening is made in the trachea, after which the tube is withdrawn only far enough to allow the tracheotomy tube to be inserted. If the obturator is left in the tracheotomy tube, the anesthesia can be continued through the endotracheal tube until the operation is completed (Figs. 13 and 14). Far too often tracheotomy has been looked on as such a formidable procedure that it has been delayed until irreparable damage has been done or a fatality has occurred. This operation may be done with facility and with very little discomfort to patients without prolonging their convalescence unduly. There should be no hesitancy in performing a tracheotomy on any patient with evidence of increasing postoperative respiratory obstruction.

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TECHNIC OF SUBTOTAL THYROIDECTOMY

FRANK H. LAHEY

In an experience with thyroidectomy now amounting to over 28,000 instances, it is inevitable that changes in our plan of the operation would occur from time to time. There have remained, however, basic principles which in my opinion cannot be violated if one wishes to obtain good results. Results may be called good only when the patient is completely relieved of the thyroid condition for which the operation was done, only when the mortality is kept, as it must be today with the antithyroid agents, well under 1 per cent and approaching that of zero, and only when morbidity, such as tetany and recurrent laryngeal paralysis, is largely absent.

Before discussing the technic of subtotal thyroidectomy, I would like to establish certain fundamental needs which I believe will be, perhaps not universally but quite generally, accepted by the majority of surgeons who have operated upon many patients for thyroid disease. The outstanding requirement for a good thyroidectomy, in my opinion, is good exposure. When one balances short incisions accompanied by attempts to remove thyroids without cutting the prethyroid muscle with the inevitable handicap which will come from the limitations of exposure related to these three factors in any large series of cases, namely, recurrent laryngeal paralysis, tetany and inadequate removals of thyroid tissue, the advantage of wide exposures with good-sized incisions and severed muscles will be convincingly demonstrated.

Skin Incisions. In writing on this subject some years ago I devoted an entire paper to the matter of thyroid incisions, not only because they are important from the point of view of adequate exposure but because a conspicuous scar, in the minds of most women, means an unsuccessful outcome of the operation. It is just as easy to place an incision in a location where it is inconspicuous as it is to place it in a position where, because it cannot be concealed, it is always conspicuous A goiter incision should have two features about it to be a good one: (1) It should be at a level where a string of beads placed about the neck will naturally rest at the junction of the neck with the chest. (2) It should have in it a gentle curve of such character, again, as to be concealed by a string of beads resting on the neck at the level where the neck joins the chest. There are some features which a goiter incision should not have, such as the following: It should not be a straight incision across the neck because that can never be made inconspicuous. It should not be of a horseshoe type because the ends can never be concealed. It should never be high on the neck because it will then always be obvious. It should never be out of balance, that is, with one end higher than the other, because it will then always be unsightly.

There have been many proposals that goiter incisions be measured by the

Originally published in Surgical Clinics of North America, 29.641–658 (June) 1949.

width of a finger or by the width of two fingers above the sternal notch. This is an impractical method of determining the level at which goiter incisions should be made. It is impractical because of the fact that necks vary in length, that is, in the distance between the chin and the sternal notch. A level of one fingerbreadth above the sternal notch may be proper in one patient but improper in another.

Goiter incisions made free hand and judged by the eye will always be superior to those attempted by such mechanical means as measuring with fingerbreadths above the sternal notch.

We have practiced here the plan of marking out proposed goiter incisions with the back point of a knife which lightly scratches the skin and permits one

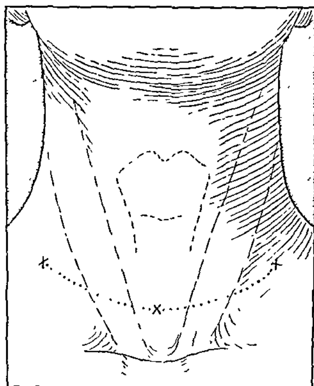


Fig. 15. Method of marking three points with the point of a hemostat along which the skin may be scratched with the back of a knife point to visualize the curve of the incision. This has proved valuable in our hands to visualize the planned incision so that if it is not satisfactory, corrections can be undertaken before the final incision is made.

to visualize where the incision will be and then correct improper levels, inadequate curves or lack of balance in the incision. In certain cases it is even of value to make the imprint of a point of a hemostat at either end of the limb of the incision and at a center point and then connect them by eye (Fig. 15). This has proved a very practical point in making incisions at proper levels, with proper curves and with good balance.

Elevation of the Skin Flaps. Another point in goiter incisions is, in my opinion, the need to elevate the skin, subcutaneous fat and platysma in one layer The easiest point at which to elevate the flaps is between the prethyroid muscles and the platysma (Fig. 16). This has the advantage of the lack of bleeding, and the particular advantage that it keeps the adipose layer of tissue between the skin and the platysma intact. If one elevates the skin flap in the

adipose layer between skin and platysma, there will be two undesirable features: (1) prompt and marked reaction to trauma as evidenced by postoperative edema and (2) the development at times of numerous small connections between the skin and underlying prethyroid tissue which will produce unsightly puckering and dimpling as the patient swallows.

The above are but minor points in the elevation of the skin flaps for subtotal thyroidectomy. The all-important one is that the incision be of sufficient length to permit adequate elevation. An added 2 or 3 inches in a goiter incision that easily makes possible the exposure of the parathyroids and the recurrent laryngeal nerves, together with the other important anatomical structures, is a good investment. We believe that all skin incisions for thyroidectomy should expose the en-

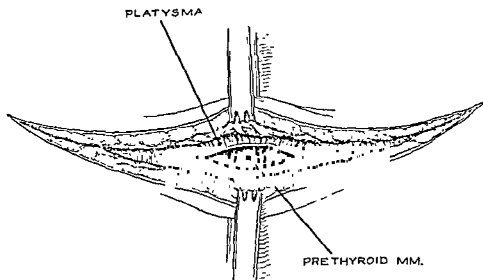


Fig. 16. Method of raising the skin flap by elevating it between the prethyroid muscles and the platysma. Note that when the platysma is raised this way the layer of adipose tissue between the skin and the platysma is preserved intact.

tire gland from the most inferior portion of its lower pole to the most superior portion of its upper pole and even a portion of the superior thyroid artery and vein. There will always be a tendency on the part of surgeons to stop the elevation of the skin flap before it has been carried to an adequate height. There will be few cases in which the skin flaps will have been adequately elevated unless the elevation is carried well above the level of the sternal notch. This elevation of skin flap can be done satisfactorily only before the prethyroid muscles are cut. I know of nothing in my entire experience with subtotal thyroidectomy that is technically as important as the adequateness of the elevation of the skin flap because it so controls the all-important feature of anatomical exposure.

Cutting the Prethyroid Muscles. Over the years as I have discussed thyroid surgery in various parts of the world I have constantly encountered a conflict of opinion as to whether or not it is necessary to sever the prethyroid muscles to do adequate subtotal thyroidectomy. I can only say in defense of our position that they should all be severed and resutured, that we have severed the muscles in literally thousands of cases, that if they are severed at a high level and resutured accurately there will be no disability or disfigurement and the exposure

will be better than when they are not severed. I feel sure that two factors enter into the unhappy results claimed by some surgeons after severing the prethyroid muscles. One is that if they are severed low, their innervation, the descending branch of the hypoglossal nerve, will then be sacrificed and this will result in disfiguring atrophy of the prethyroid muscles with the sunken neck and the prominent trachea. The other is that if they are severed low, their

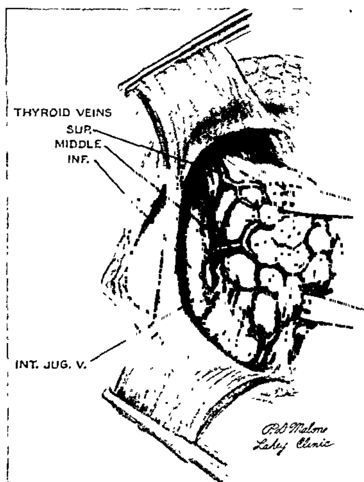


Fig. 17. The muscles are severed and the gland is pulled upward and inward and is seen lifted out of its bed. This illustrates the all-important step of demonstrating and ligating the superior, middle and inferior thyroid veins so that the layer between the trachea and esophagus on the inside and the internal jugular vein and the common carotid artery on the outside can be freed to expose the important anatomical contents here, the inferior thyroid artery, the recurrent laryngeal nerve and the parathyroid glands.

suture line will be close to the level of the skin suture line which will bring about undesirable wound complications. If the prethyroid muscles are severed high, no one can deny that it will add to the wideness of the exposure, the ease of the operation and, in my opinion, will definitely diminish surgical accidents which can occur in dealing with the complicated and delicate anatomical structures which must be dealt with in any thyroidectomy.

Severance of Venous Tributaries of Internal Jugular Vein. With the prethyroid muscles severed and grasped by double hooks to hold them up and down, the thyroid gland immediately comes into view. The next important step is based on the fact that one cannot mobilize the thyroid gland so that it can be

lifted out of its bed until its connections to the internal jugular vein are completely severed and ligated. The anatomy of the venous tributaries draining from the thyroid into the internal jugular, while varying at times, is relatively constant. There is a small vein going from the upper pole of the thyroid directly into the internal jugular, there are one, two or even three or four veins running

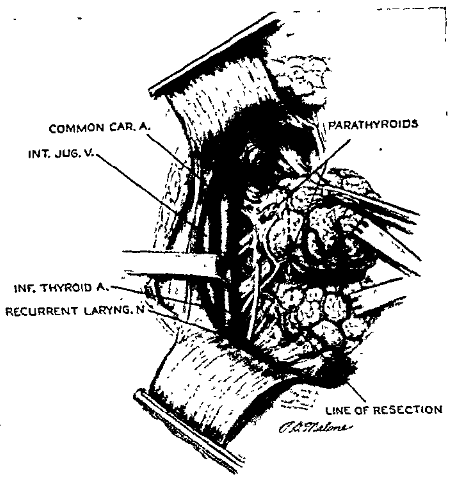


Fig 18. The veins running between the thyroid gland and the internal jugular vein are completely severed, the gland is lifted out of its bed, and the region between the trachea and the common carotid freed so that the inferior thyroid artery and the recurrent laryngeal nerve are exposed to view. In this illustration is shown a step which is not done until the lower pole has been mobilized, but for the purposes of demonstrating the most common position in which the upper parathyroid is found, the superior thyroid pole is shown here, demonstrated as severed

Note in this illustration the recurrent laryngeal nerve running over the inferior thyroid artery. Note the relationship of the upper parathyroid and the recurrent laryngeal nerve as it enters the larynx in a position behind the larynx where it rests before the superior thyroid artery and vein are severed, and the upper pole mobilized away from the larynx and inward to expose the parathyroid.

from the middle portion of the thyroid to empty directly into the internal jugular, and there is a quite constant group of inferior veins running from the lower pole of the thyroid to empty into the internal jugular. With the thyroid gland grasped by the goiter double hooks which we have devised, and lifted gently out of its bed, these veins may be put upon the stretch, they may be identified by blunt scissors dissection, double-clamped and severed. With all of these veins severed and ligated, the thyroid gland can then be so delivered from its bed

that it hangs only by the attachment of its body to the trachea and the side of the larynx. This immediately reveals the region where the important anatomical detail of the thyroid is, that is, the region of the inferior thyroid artery, the recurrent laryngeal nerve and the parathyroids.

Identification of Internal Jugular Vein and Common Carotid Artery. The next important step is the accurate demonstration of the internal jugular vein and the common carotid artery. By the retraction of these two structures

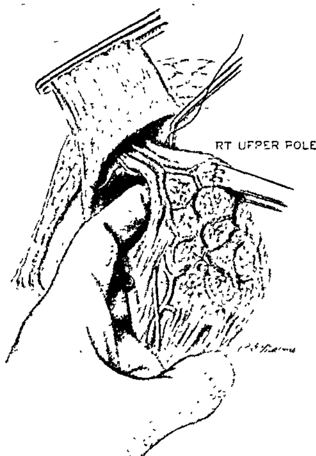


Fig. 19. Method of separating the upper pole of the thyroid from its attachment to the larynx so that the vessels can be completely freed and a ligature passed around them so that it does not include any of the apex of the upper thyroid pole. Note the fingertip placed beneath the upper pole to lift it away from the larynx.

This maneuver insures safe ligation of the superior thyroid artery and vein and, even more important, permits mobilization of the upper pole of the thyroid away from the larynx so that the parathyroid which rests against the larynx and behind this lobe can be exposed and preserved.

by means of a special blunt retractor (Fig. 17), the anatomical structures in the region of the inferior thyroid can at once be visualized. As one observes in Figures 18 and 19 it becomes obvious that the important anatomy of the thyroid can be demonstrated only by the maneuver which I have stressed many times in writing upon this subject, that is, the severing and ligating of the connections of the veins draining from the thyroid into the internal jugular. Whenever I see a thyroidectomy done without this technical step being completed, I know that one of two things will result. There will be a very bloody field because of the

venous oozing or there will be only a severing of the top layer of the thyroid and that portion which rests in the groove between the common carotid and the trachea and the esophagus will be left behind—an inadequate subtotal thyroidectomy.

Demonstration and Isolation of Inferior Thyroid Artery. With the common carotid and internal jugular retracted outward, the layer of tissue between these two vessels and the trachea and esophagus can then be gently opened by blunt dissection with scissors until the point is reached where the inferior thyroid artery can be visualized as it appears from behind the common carotid artery.

It is important to realize that the level at which the inferior thyroid artery appears behind the common carotid artery varies greatly. It most constantly appears at about the level of the midportion of the body of the thyroid gland. It can, however, ascend in a loop and be found at a level as high as the superior thyroid pole from which it descends in another limb to enter the midportion of the thyroid body. It can, on the other hand, arise out of the chest as a straight line going directly upward from the chest into the body of the thyroid gland.

The demonstration of the inferior thyroid artery is important not only from the standpoint of being able to control the arterial blood supply to the thyroid but because the inferior thyroid artery plays an important part in the identification of the recurrent laryngeal nerve. In a majority of cases the inferior thyroid nerve will pass beneath the inferior thyroid artery. In other cases, in the neighborhood of 40 per cent, it will pass over and above the inferior thyroid artery, and so by identification of the inferior thyroid artery, one can follow its course until it enters the thyroid and be able to say immediately whether or not the nerve is above or below the artery. If it is above, it can readily be seen; if it is not, one immediately knows that it must be sought below the artery by further dissection. If the recurrent laryngeal nerve passes above the inferior thyroid artery, it is in much greater danger of injury than when it passes beneath, owing to the fact that, as the thyroid is elevated from its bed, the inferior thyroid artery is also elevated and so the nerve is pulled up out of its deep position where it can be more easily grasped by a hemostat with which one seeks to control bleeding veins.

Finding and Isolation of the Recurrent Laryngeal Nerve. Following the demonstration and isolation of the inferior thyroid artery, which is usually in the form of a single trunk but can and does sometimes divide into two trunks behind the common carotid artery, the next all-important step, even before the inferior thyroid artery is ligated, is the finding and demonstration of the recurrent laryngeal nerve. The recurrent laryngeal nerve arises, with few anomalous exceptions, out of the chest to ascend obliquely, as shown in Figure 17, to the horn of the thyroid cartilage where it disappears below the lowest fibers of the inferior constrictor to enter the larynx and to innervate the arytaenoideus posticus and the arytaenoideus lateralis, the two muscles controlling abduction and adduction of the vocal cords. The recurrent laryngeal nerve is to be found only with an intense light, and in a field which is completely dry and free from bleeding. In finding the nerve the scissors are gently opened and the tissues spread apart, opening the scissors always in the direction of the course of the

nerve to avoid stretching it. There will occasionally be found small, delicate veins within the areolar tissue between the common carotid, the trachea and the esophagus, but most frequently this region is relatively free from blood vessels and one has little difficulty in exposing the recurrent laryngeal nerve. It can be recognized by its longitudinal fibers, by the fact that there is often a small vessel which runs along the nerve to indicate the two sections of the nerve, the smaller section representing the abductor fibers and the larger section representing the adductor fibers. If there be any doubt as to whether or not a structure seen running in a proper course is or is not a nerve, I have been greatly aided by using the Berens-Beebe binocular loupe which will magnify the structure two and a half times and make it possible to distinguish nerve from vein.

Ligation of Inferior Thyroid Artery. Once the nerve has been identified, the inferior thyroid artery is then immediately tied as a trunk. We have not made it a custom to sever the inferior thyroid artery and I have a distinct feeling that this is undesirable as a routine measure. One ligates the inferior thyroid artery to control bleeding and by ligating it in continuity he avoids the added danger of the tie being blown off by the powerful thrust which occurs in the inferior thyroid artery. Postoperative bleeding from a loose inferior thyroid artery causes a most serious type of postoperative hemorrhage.

There will be certain instances in which it will be desirable to ligate the inferior thyroid artery between two ties and sever it. Those cases will be the ones in which it seems desirable to follow the recurrent laryngeal nerve up to the point where it enters the larynx, particularly when the nerve is beneath the artery. There will be other cases in which a search is made for a parathyroid in order to demonstrate the anatomical preservation of one on each side as we have, in the last several years, attempted to do in every case. In such cases severing of the artery and turning up of the inner branch will often expose to view a parathyroid behind the artery that could not have been found otherwise.

There have been many visitors who, in observing our operations upon patients particularly with toxic goiter, have inquired as to whether or not the ligation of all four vessels, both inferior thyroid arteries and both superior thyroid arteries, has resulted in any undesirable complications, such as tetany, as relates to the blood supply of the parathyroids. We can say, without reservation, that we have ligated all four vessels, both superior thyroid arteries and both inferior thyroid arteries, in thousands of cases with no indication that this has resulted in any loss of blood supply to the parathyroids or any other undesirable complications.

Demonstration of Trachea. With the inferior thyroid artery ligated and the recurrent laryngeal nerve demonstrated, the next important step is to demonstrate the trachea, and the vessels (the inferior thyroid vein and rarely the thyroidea ima artery) running from the isthmus of the thyroid down behind the sternum. A hemostat clasp is carefully passed beneath these vessels, close to the trachea, they are grasped by two hemostats below and one hemostat above, and severed by a knife between the upper one and the lower two, leaving the hemostats behind to protect the trachea. Two hemostats, as shown in Figure 20, are applied to the veins going to the isthmus in order that a tie may be placed about these veins running to the lower poles of the thyroid, one hemostat taken off, another tie again placed, and the remaining hemostat taken off. It has been our

experience that when these veins running to the lower pole of the thyroid escape from a hemostat, retract behind the sternum and produce a hematoma, it is difficult to recover them again satisfactorily because of the retrosternal hematoma. For that reason we believe the additional precaution of double clamping is well worth while. With the veins running to the isthmus tied below and above, the

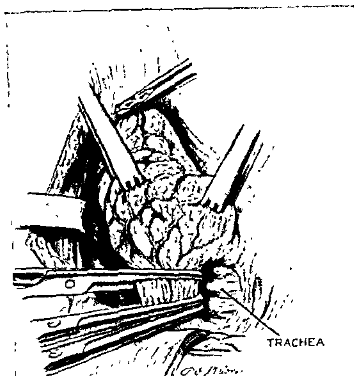


Fig. 20. Method of grasping with hemostats the inferior thyroid vein and the occasional thyroidea ima artery as they enter the lower pole of the thyroid. Note that the trachea has been completely bared and, as shown in Figure 18, the recurrent laryngeal nerve has already been completely exposed so that there is no danger of including it in the clamps which grasp the isthmus. Note in Figure 18 that the vessels running to the lower pole of the thyroid are clamped and cut, the lower pole of the thyroid is grasped with double hooks and lifted upward so that it can be freed from the trachea in order to mobilize it inward and the portion of the thyroid external to the dotted line marked "line of resection," which is left behind, will be but a small remnant. Note in Figure 18 also that the upper pole of the thyroid with the superior thyroid is cut and pulled down and the lower pole up in order that the remaining remnant, marked by the dotted line labeled "line of resection" will be but a small one.

lower pole is then detached gently from the trachea and pulled upward, as shown in Figure 18.

Ligation and Severance of Superior Thyroid Vessels. The next step in the thyroidectomy consists of grasping the upper pole of the thyroid (Fig. 17) and so pulling it to the inside that it can be separated from the point where it rests against the larynx so that the fibers of the inferior constrictor muscle can be well visualized. If the upper pole of the thyroid is pulled away from the larynx in this way, the blood supply consisting of the superior thyroid artery and vein can be clearly seen and ligatures placed about them by the special passer shown in Figure 19 which I devised a number of years ago and which

we have since employed continuously. This permits the accurate passing of a No. 1 plain catgut tie about the pole so that it is possible to tie these vessels well off the thyroid gland itself. This is an important point because unless there is good exposure of the upper pole there will be occasional cases in which the tie includes a portion of the upper pole of the thyroid gland so that the knot cannot be shut down completely and there will be added danger of its being pushed off, resulting again in serious arterial hemorrhage postoperatively. Nothing which we have done has been of greater value to us in accurate control of the superior thyroid artery than ligation and religation of the thyroid gland under direct vision.

When one visualizes the anatomical situation in ligation of the superior thyroid artery, it is surprising that more hemorrhages do not occur following ligation and severance of this vessel. It is to be recalled that the superior thyroid artery is the first branch of the external carotid, that it is directly at the carotid bulb where there is a tremendous volume of blood thrust as it passes up the bulb into the internal and external carotids. If this artery is cut short, there will be a constant tendency, owing to the vigorous thrust which persists in the ligated stump, for the tie to be pushed off—a misfortune which has happened to us in the past on more than one occasion and was responsible for one serious postoperative emergency.

Mobilization of Upper Pole of Thyroid Downward. With the superior thyroid vessels ligated and severed, the upper pole of the thyroid can now be turned downward and inward. This makes it possible to accomplish a radical removal of the thyroid. Without mobilization of the superior pole downward and inward, it will be possible to perform subtotal thyroidectomy only by leaving long strips of thyroid attached to the trachea and the larynx. By means of mobilizing the lower pole upward and inward and the upper pole downward and inward, the gland can be so compressed that only small sections of thyroid will remain after subtotal thyroidectomy. To my mind, this has played an important part in increasing the radicalness of our subtotal thyroidectomies over the later years and so diminishing the incidence of postoperative persisting hyperthyroidism.

Identification of Superior Parathyroid. With the upper vessels ligated and the upper pole turned down one should, with the aid of the Berens-Beebe loupe and good light, immediately begin the search for the superior parathyroid which is so constantly present behind the upper lobe of the thyroid as it rests against the larynx. So constant is the superior parathyroid in this position behind the larynx where it is protected by the upper pole resting against the side of the larynx that there will be only occasional cases in which it will not be possible to identify it and preserve it. We have now for a number of years insisted that every attempt be made to identify, demonstrate and preserve one parathyroid on each side when subtotal thyroidectomy is done.

Outlining Section of Thyroid to Be Removed. With the upper pole pulled down and the lower pole pulled up, a line of hemostats is now inserted in the outer surface of the thyroid gland to mark out the portion which is to remain behind as the thyroid remnant upon which the patient will exist. We

have developed over the years a special type of hemostat, as shown in Figure 21, in which the stampings run from the point of the hemostat completely down to the place where they cross for the lock. These have been developed in order that they may hold throughout the course of the distances at which they are plunged into the thyroid gland and avoid pulling out at the heel of the thyroid which occurs with those hemostats in which the markings are only partly stamped down the jaws. With this line of hemostats introduced, an incision is made along this line in the downward direction, not in a transverse direction, to mark out the section of the thyroid which is to be removed (Fig. 18).

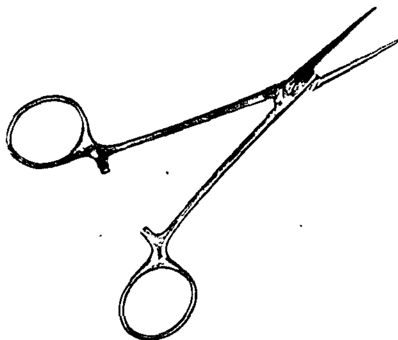


Fig. 21. Photograph of a hemostat with the jaws stamped from tip to heel in order to hold thyroid tissue throughout its extent.

Resection of the Gland and Suture of Remnant to Trachea. The isthmus is now grasped with double hooks and hemostats are gradually inserted between that structure and the trachea until the isthmus is mobilized from the trachea, which can readily be done with a very small amount of bleeding. As the isthmus is freed from the trachea, hemostats grasp the groove which was originally made in the body of the thyroid. These, as they are applied, are severed by scissors until the entire lobe is freed from the remnant which is to be left behind and the isthmus is entirely freed from its attachment to the trachea. As the isthmus is dissected its attachment to the left lobe is gradually clamped until the entire isthmus and that portion of the thyroid which is to be resected are entirely removed (Fig. 22).

It is to be recalled that at all times during the course of this procedure the recurrent laryngeal nerve is visible and one can be certain by frequently identifying it that it is not injured.

All vessels are now tied and it has been our custom never to tie multiple groups

of hemostats but to tie each one individually in order that large segments of thyroid tissue shall not be tied in and thus endanger the blood supply to the parathyroids or cause injury to the recurrent laryngeal nerve.

If the line of incision in the body of the thyroid after the identifying hemostats have been inserted is made in an oblique and downward direction, when all of the blood vessels have been tied it will be found that the thyroid remnant remaining will fit well against the trachea to which it is then sutured, as shown

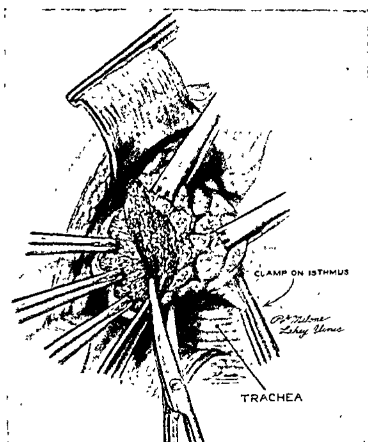


Fig. 22. The segment of thyroid into which the hemostats are plunged and which is to represent the segment of thyroid remaining is shown in the outer portion of the illustration. In the inner portion, the isthmus on the opposite side is shown as clamped, the isthmus has been completely separated from the trachea and the section of thyroid previously adherent to the trachea is being severed by scissors until the entire lobe on that side is completely freed.

With this portion of the operation completed, the entire right lobe of the thyroid except for the remnant which remains, together with the entire isthmus, is removed.

in Figure 23. There has been nothing comparable with this plan which made it possible for us to perform subtotal thyroidectomy even in the case of very vascular hyperplastic glands before the days of antithyroid agents and still be able to close the wound without drainage.

We have employed double zero plain catgut sutures which are introduced to the edge of the thyroid remnant and then grasp the side of the larynx and the fascia over the trachea so that when the knots are tied the cut oozing surface of the severed thyroid is snugly placed against the trachea for control of bleeding (*Fig.* 23).

I do not wish to give the impression that this method of suture will control

active, pulsating bleeders which must be tied, but it will control the oozing which will otherwise occur frequently from the cut surface of the thyroid.

Left Subtotal Hemithyroidectomy. With the completion of the right subtotal hemithyroidectomy, the left subtotal hemithyroidectomy is undertaken in the same way, again identifying the venous tributaries leading to the internal jugular vein, and the inferior thyroid artery, the recurrent laryngeal nerve, the isthmus, the vessels leading to the isthmus, the superior thyroid artery, and again mobilizing the upper pole from the larynx and identifying the parathyroid behind the upper pole as it rests against the larynx.

There is but one technical point to be added to the plan of left subtotal hemithyroidectomy as compared with the right. One must be careful as the isthmus

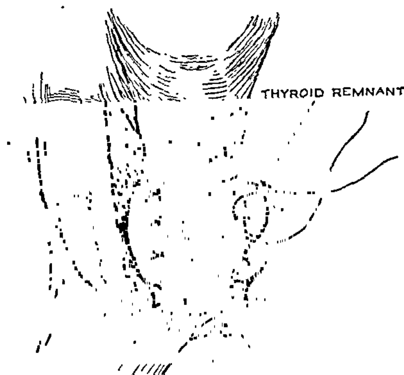


Fig. 23. This illustration, as seen in other technical descriptions of subtotal thyroidectomy, shows the remnant of thyroid remaining which has been sutured against the trachea with 0 catgut stitches between the fascia covering the trachea and the edge of the thyroid so that the cut surface of the thyroid with all of its vessels tied is sutured against the trachea to control oozing

is elevated off the trachea and as the subtotal thyroidectomy is conducted as described for the opposite side to be sure to identify pyramidal lobes, to follow them up to the point where they so often go, that is the level of the hyoid, and to remove them thoroughly.

I know of nothing which can produce greater disfigurement than leaving behind a pyramidal lobe which later becomes hypertrophied and sticks out on the neck like a thumb of tissue. It not only is a most disfiguring remnant but, as a result of the hyperplasia, sometimes causes recurrence of the hyperthyroidism.

Retying of Superior Thyroid Arteries. With the subtotal thyroidectomy now completed on both sides, both superior thyroid arteries are again widely exposed and identified. Both are grasped with right angle clamps and are retied at a higher level than the original ligation with No. 2 plain catgut. This I would

strongly urge upon everyone who is dealing with subtotal thyroidectomy. It is an additional precaution against the possibility of the original tie slipping off and it will give one an added sense of confidence with regard to possible postoperative hemorrhages.

Closure of the Wound. Closure of the neck requires little description. Prethyroid muscles are carefully sutured with No. 2 plain catgut, employing mattress sutures. Care should be taken not to include too wide ends and yet on the other hand to include enough of the cut ends of the muscle within the Ochsner clamp to hold the mattress sutures firmly. One must make absolutely certain

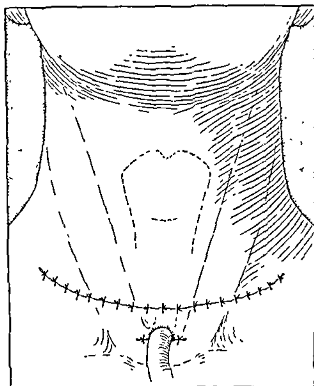


Fig 24. The counter incision, first suggested by Kocher, through which it was the practice to bring a drain. This has two disadvantages: (1) the counter incision in the skin can never be concealed and (2) the drain passes between the fibers of the prethyroid muscle so that when it is withdrawn the trachea becomes adherent to the skin and ascends and descends with swallowing

that the large venous channels running on the prethyroid muscles are accurately controlled and great pains must be taken to inspect carefully all of the wound against the possibility of leaving behind bleeding points which will result in the accumulation of hematomas beneath the skin that will require reopening of the wound. This unfortunate complication will occasionally occur in spite of every precaution, but will occur less frequently if one takes great pains to control all of the vessels.

There have been many debates concerning whether or not the platysma should be sutured. We can only say that we have never sutured the platysma. We believe that suture material placed in the platysma beneath the skin edge adds to wound complications. We do not believe that there is any danger of the platysma pulling the scar apart and we have obtained excellent wounds without the use of platysma sutures.

For many years we have closed wounds with Michel's skin clips. Good scars are obtained, their excellence depending on how painstakingly and accurately the skin edges are approximated.

If one leaves skin clips on longer than three days, there will be unsightly pinprick holes and for that reason half of the clips are taken out on the second day and the other half on the third day. There will never be any danger of the wound pulling apart, because even if the patient were to vomit or raise his chin, the pull will be not on the skin but on the sutured prethyroid muscles and will cause him to stop the movement immediately.

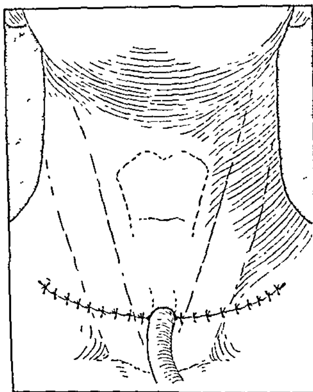


Fig. 25. This incision in which the drain is brought out through the central portion of the wound does not have the disadvantage of a disfiguring counter incision but does have the disadvantage of the skin becoming adherent to the trachea where the drain has been passed between the two sets of fibers of the prethyroid muscle so that it becomes adherent to the skin and ascends and descends with swallowing.

Use of Drains. While we have closed almost all of our thyroidectomies without drainage, there have been occasional cases in which, because of undesirable oozing or because large adenomas have been removed, drainage was necessary. I would like to urge two or three points in respect to drainage. One should never make the counter-incision as shown in Figure 24, which was suggested by Kocher, because this will produce a scar that can never be covered. One should never bring a drain out to the middle portion of the wound (Fig. 25); this will require it to be brought out between the prethyroid muscles and when the drain is removed the skin will become adherent to the trachea by scar tissue so that it will ascend and descend in an undesirable *way upon swallowing.*

In Figure 26 is shown the method that we employ in the use of drains. The drain is brought out through the belly of the sternomastoid muscle and to the

outer angle of the wound. This results in sutured muscle being interposed between the entire skin flap and the trachea. When the drain is withdrawn, the aperture through the sternomastoid will close and adhesions will not be estab-

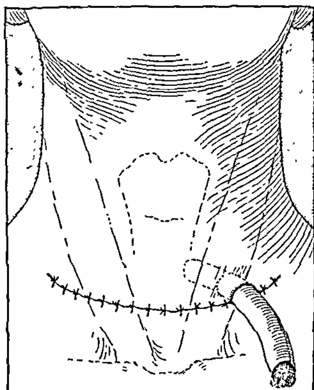


Fig. 26. Method of introducing the drain through the fibers of the sternomastoid and bringing it out through the corner of the wound. This permits complete closure of all of the prethyroid muscles in the middle line and interposes a layer of muscle between skin and trachea so that the latter does not become adherent to the skin and produce the unfortunate bobbing up and down as the patient swallows.

lished between the skin scar and the trachea. Thus the disfigurement and undesirable bobbing up and down of the skin upon swallowing, which occurs when drains are placed in the wound in other positions than that shown in Figure 26, will not result.

SURGICAL TREATMENT OF HYPERTHYROIDISM

RICHARD B. CATTELL

Subtotal thyroidectomy has been conclusively demonstrated to be effective in the treatment of hyperthyroidism, both for the adenomatous or nodular type and for the primary or diffuse toxic type. In experienced hands, the operation can be performed with an operative mortality of 1 per cent or less and with few complications. Furthermore, satisfactory results are achieved in 90 to 95 per cent. The operation, as carried out today, has reached a high state of perfection but such has not always been the case. Indeed, the high incidence of complications which has been reported in earlier series, including an appreciable number of recurrences of the disease, has frequently been quoted in the literature as reason to employ an operation only as a last resort after failure to control symptoms by so-called conservative measures. That such a situation should not exist today will be pointed out in this presentation, which will review experiences at the Lahey Clinic in the surgical treatment of 1,000 consecutive cases.

The employment of thyroidectomy in the treatment of hyperthyroidism can properly be divided into three periods. The first might be termed the pre-iodine era, i.e., prior to 1923. During this time operation was hazardous and surgery was performed under difficult circumstances, yet technical methods were developed which formed the basis for the present-day operation of subtotal thyroidectomy. The second period, from 1923 to 1943, can be considered the iodine era, during which time iodine was used in the preoperative preparation of patients. This led to a marked reduction in surgical mortality and postoperative complications. During this entire period the operation of subtotal thyroidectomy was greatly improved and became more effective. The third period, since 1943, following the introduction of the antithyroid drugs has again modified the treatment of hyperthyroidism. This discussion will be limited to the last period.

During the six-year period, May 1943 until May 1949, 1,630 patients with hyperthyroidism have been prepared for subtotal thyroidectomy by the use of antithyroid drugs. This paper will consider the first 1,000 patients. Although five different preparations have been used, propylthiouracil has been the drug of choice in most cases. The routine preoperative preparation of patients by the antithyroid drugs is supplemented by the administration of iodine during the last two or three weeks of the treatment. Early in the six-year period, an appreciable number of patients with hyperthyroidism continued to be prepared with iodine alone but this preparation was chiefly confined to the milder cases and more recently the number so prepared has been small.

In reporting this experience it is important to realize that the surgery has been performed by nine different surgeons and represents their combined ex-

Originally published in Journal of Clinical Endocrinology, 9.999–1006 (Oct.) 1949.

perience during this six-year period. The preoperative preparation of these patients has been under the direction of the medical department of the clinic, chiefly in the hands of Dr. Elmer C. Bartels and Dr. George O. Bell. Detailed information relative to all cases both before and after operation has been kept by Dr. Bartels and Dr. Bell, and I am indebted to them for many of the detailed figures. During the six-year period there has been no selection of cases, so that mild and severe cases are included as well as all of the poor risks. Fourteen per cent of the patients fell in a group known as thyrocardiacs and among the total was an appreciable number of children under 13 years of age and patients with diabetes mellitus.

Advantages of the Surgical Treatment of Hyperthyroidism

There are many reasons why thyroidectomy should be employed in the treatment of patients with hyperthyroidism. Operation has had a long period of trial and has proved to be very effective. Many follow-up studies have been made which demonstrate that the relief of symptoms is maintained permanently in 90 to 95 per cent of patients. Operation can be carried out with a low mortality and with few complications. The evidence so far indicates that it probably results in the relief of more of the symptoms and signs of the condition than any other method and is probably essential in most diffuse nodular goiters complicated by hyperthyroidism. It possesses a great advantage when large numbers of patients apply for treatment, as is the case in our Clinic where approximately 500 new patients with hyperthyroidism undergo treatment each year. At the present time only a five- or six-day total hospital stay is required and most patients are able to return to work in a period of two to four weeks after operation. Thyroidectomy offers a rapid and predictable result. Based on our experience in the treatment of a large number of patients with hyperthyroidism, we consider it the best method for treatment.

Preparation with Antithyroid Drugs: Effect on Subsequent Thyroidectomy

Without any question, the technical difficulties of thyroidectomy are increased when patients have been prepared with the antithyroid drugs. In our earlier experience the gland was found to have a greatly increased vascularity and to be very friable. The appearance of the gland was not unlike that observed in patients before the use of iodine. Most of these technical difficulties have been overcome by causing involution of the gland by the administration of iodine during the latter part of the preoperative period but it still remains necessary to exercise the greatest care in carrying out the procedure, in order to avoid the complications that may follow thyroidectomy. This became evident soon after the employment of the antithyroid drugs when, as reported in an earlier review, a higher incidence of complications was noted than in patients prepared with Lugol's solution. The most striking result that has been obtained is the reduction of operative mortality. In the twenty-year period preceding 1943, the operative mortality for all patients with hyperthyroidism was approximately 1 per cent, and in a selected group of patients, the thyrocardiacs, it was approximately 3 per cent.

Operative Procedure

All thyroidectomies were carried out under general anesthesia, utilizing nitrous oxide-oxygen-ether or ethylene-oxygen-ether anesthesia. The majority of patients had the anesthetic given through an endotracheal tube. Cyclopropane has not been used because of its effect on the heart, particularly as evidenced by changes in rhythm. No patients have been operated on under local anesthesia.

The technic of subtotal thyroidectomy will not be described. The operation is carried out routinely by the division of the prethyroid muscles and with a wide lateral dissection and exposure. All four thyroid arteries are ligated, the superior thyroid vessels being ligated and divided and the inferior thyroid arteries ligated in continuity (see Fig. 18, p. 31). Two or more parathyroids are routinely visualized. The recurrent laryngeal nerves are likewise routinely exposed as the most effective means of avoiding injury (Fig. 18). The major portions of both lateral lobes and all of the isthmus and pyramidal lobes are resected, leaving small segments of the lateral lobes which are folded over to the laryngeal and tracheal fascia see Fig. 23, p. 39). The wounds are routinely closed without drainage. This brief account of the procedure is outlined in order to evaluate the postoperative complications.

CLINICAL DATA

In the six-year period, May 1, 1943, to May 1, 1949, 1,630 patients with hyperthyroidism have been operated on at the Lahey Clinic. This includes all patients who have been prepared with any of the antithyroid drugs before operation. An analysis of the first 1,000 of these patients will be presented.

Type of Goiter. In the first 1,000 consecutive patients operated on, there were 184 patients with adenomatous goiter with secondary hyperthyroidism. This includes the discrete nodular as well as the diffuse nodular goiter with hyperthyroidism, representing 18.4 per cent of the cases. There were 816 patients with primary hyperthyroidism (Graves' disease, exophthalmic goiter), or 81.6 per cent. In this group of 1,000 patients, 135 were listed as thyrocardiacs, these patients having either well-established auricular fibrillation or cardiac decompensation.

Operative Mortality. In the total group of 1,630 patients there were 4 deaths, an operative mortality of 0.24 per cent. In the first 1,000 operations only 1 operative fatality was encountered, a mortality of 0.1 per cent. Two of the 4 deaths were from cardiovascular complications. The first death occurred suddenly, without warning, on the second postoperative day, without any evidence of postoperative reaction. Postmortem examination revealed a coronary thrombosis. The second death occurred as the result of cardiac arrest in the operating room. The third and fourth deaths were due to tracheal obstruction and must be regarded as preventable. Tracheotomy was performed in both patients within a few hours of the onset of obstructive symptoms, but must be considered to have been done too late for a successful outcome.

Postoperative Hemorrhage. Postoperative bleeding has always been a possible complication of thyroidectomy. Arterial hemorrhage has been effectively controlled by ligation of all four thyroid arteries but *may still occasionally be*

encountered in spite of this technical precaution. Most of the bleeding encountered is from the veins of the skin flap or the anterior jugular veins but at times the inferior thyroid veins may not be adequately secured. In 1,000 consecutive patients undergoing thyroidectomy it was necessary to open the incision in 27, or 2.7 per cent. It is our practice to open any wound that becomes puffy or ecchymotic, since there is always the possibility of these conditions being followed by some degree of respiratory obstruction. In any doubtful case it seems advisable to open the flap and make certain that all bleeding is controlled.

Respiratory Obstruction Requiring Tracheotomy. Thirteen patients out of the group of 1,000 had tracheotomy performed either at the time of operation or soon afterward, usually within forty-eight hours. Any patient with signs of respiratory obstruction has immediate indirect laryngeal examination and if the airway is encroached upon by edema or there is limited motion of the vocal cords, tracheotomy is performed at once. It should be emphasized that tracheotomy should be performed in any doubtful case, since a mild degree of respiratory obstruction may rapidly become a complete obstruction with little further warning. In the 2 fatalities that occurred from this cause, the tracheotomy was performed four and six hours respectively after the first symptoms occurred, yet this proved to be too long an interval. Nurses, interns, residents and staff physicians must all be aware of this possibility and the necessity for immediate action in order to avoid the rare fatality that may result.

In this group of 13 patients in whom a tracheotomy was performed, were 3 patients who had preoperative myxedema produced by the use of the antithyroid drugs. This occurred early in our experience and it is now appreciated that respiratory obstruction is very likely to develop in any patient with myxedema under these circumstances. Each patient routinely has a metabolism test on the day that he is scheduled for operation. If the metabolism is found to be depressed below normal, the operation is cancelled, blood is taken for determination of (fasting) cholesterol, and the patient is discharged from the hospital. Iodine medication is continued but no further antithyroid drugs are given for a period of two to four weeks. In our more recent experience, after recognition of this possibility, respiratory obstruction from this cause has not occurred.

Parathyroid Tetany. The incidence of postoperative parathyroid insufficiency has increased considerably since the use of the antithyroid drugs. There is no definite evidence to support the view that the antithyroid drugs affect the parathyroids adversely. No change has been noted in their gross appearance or on microscopic section. Most likely the higher incidence observed is related to the increased technical difficulties which have been present. Fifteen, or 1.5 per cent, of the 1,000 patients operated upon have had a persisting tetany of some degree. An equal number has had transient symptoms lasting a short period with spontaneous recovery. In a review of an earlier series of cases, the incidence of parathyroid tetany was well below 1 per cent. The present incidence of this complication indicates to us that it is essential to visualize at least two of the parathyroids when performing a subtotal thyroidectomy.

Postoperative Hypothyroidism. The incidence of postoperative hypothyroidism remains the same after subtotal thyroidectomy in patients prepared with Lugol's solution and in those prepared with any of the antithyroid drugs and

Lugol's solution. Forty-five patients in the 1,000 cases, or 4.5 per cent, have required the administration of desiccated thyroid for a considerable period. Some of this number have been able to discontinue their medication after a few months. Hypothyroidism is not a serious complication and cannot be considered to be an unsatisfactory result.

Recurrent Hyperthyroidism. A survey has not been completed of the entire group of 1,000 patients reported in this series. From this group of patients who have been followed for two years or more, 381 patients have been observed by clinical examination and by determination of the basal metabolic rate. Nine patients have been observed to have a recurrence of hyperthyroidism—a rate of 2.4 per cent. Five of these patients have been submitted to a second operation and have had complete relief of symptoms. In four the disease has been satisfactorily controlled by iodine medication. This incidence of recurrent hyperthyroidism is approximately the same as in our earlier reports of series of patients who had been prepared with iodine. We have been led by this experience to increase the amount of the gland that is removed at thyroidectomy.

Table 1. Surgical Treatment of Hyperthyroidism. Summary—1000 Patients

	PER CENT	
Hemorrhage	2.7	8.5 (Hemorrhage, Tracheotomy, Postoperative hypothyroidism)
Tracheotomy	1.3	
Postoperative hypothyroidism	4.5	
Tetany	1.5	5.1 (Tetany, Nerve injury, Recurrence, Mortality)
Nerve injury	1.0	
Recurrence	2.4	
Mortality	0.2	

Recurrent Laryngeal Nerve Injury. Injury to one or both recurrent nerves has always been a serious complication of thyroidectomy. This led Dr. Lahey, in 1937, to recommend routine exposure of both the recurrent laryngeal nerves during operation in all cases. Two years ago I reported our experience with approximately 10,000 thyroidectomies in which, by routine exposure of the nerves, we decreased the incidence of unilateral nerve injury by two-thirds. In the present series of 1,000 patients, unilateral nerve injury was found in 10, or 1 0 per cent. In addition to this small number, there were other patients who had temporary immobility of the cord as observed by indirect laryngeal inspection. We do not believe this is related to exposure of the nerve but rather to edema as a result of thyroidectomy.

In Table 1, I have made a summary of the complications and sequelae of thyroidectomy in 1,000 consecutive patients prepared with antithyroid drugs and iodine. If one includes the patients who have postoperative bleeding and those in whom a tracheotomy was necessary, 4 per cent of the patients have technical complications which cause difficulty during the immediate postoperative period but which do not interfere subsequently with obtaining a good result. About an equivalent number, or 4.5 per cent, require the administration of desiccated thyroid after operation, making a total of 8.5 per cent. Operative mortality and recurrent laryngeal nerve injuries are found to have a very low incidence. It is very essential that every effort be made to reduce the incidence of parathyroid

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insufficiency and recurrence of the hyperthyroidism, since these two groups constitute 4 per cent of unsatisfactory results.

CONCLUSIONS

Surgery is the most satisfactory method of treatment for most patients with hyperthyroidism. It should be employed, with few exceptions, in patients with nodular goiter with hyperthyroidism.

Subtotal thyroidectomy can be carried out with a low operative mortality which has been further lowered to 0.2 per cent by the utilization of the antithyroid drugs in the preparation of patients for operation.

When antithyroid drugs are used in the preparation of patients for surgery, larger portions of the thyroid gland should be removed than after preparation with iodine.

Following subtotal thyroidectomy satisfactory results are obtained in 95 per cent of patients.

THE SURGICAL TREATMENT OF PROGRESSIVE EXOPHTHALMOS

JAMES L. POPPEN

Exophthalmos is noted in about 60 per cent of patients with primary hyperthyroidism. In a large series of cases of primary hyperthyroidism, Cattell[1] found that 21 per cent showed persistence of the preoperative exophthalmos, but in only 1.1 per cent did an increase occur following operation. It is with the latter group that we are particularly concerned as neurosurgeons, since, in a few of these patients (approximately 1 in 1000 patients with primary hyperthyroidism) exophthalmos will progress to such a degree that orbital decompression is necessary to save the patient's eyesight. It is important to note that progressive exophthalmos does not necessarily occur in patients with primary hyperthyroidism. In 2 patients chronic thyroiditis was the etiologic basis, and in 6 patients toxic adenoma; the other 58 patients had primary hyperthyroidism.

Naffziger,[2] in 1931, first described a surgical technic for the relief of certain patients in whom the severe form of progressive exophthalmos develops. By means of this technic he was able to decompress the orbital contents transcranially. Because of this foresight the eyeballs of many patients have been saved in recent years. Previous surgical attempts had failed to save the eyeballs in severe progressive exophthalmos in most instances. In only the less malignant cases did canthotomy, canthoplasty and tarsorrhaphy, sympathectomy and other less radical attempts at orbital decompression save the eyeballs.

Our experiences with orbital decompression began in 1933.[3, 4] Seventy-nine patients have been operated on for severe, progressive exophthalmos. Of these, 31 were males and 48 females. Their ages ranged from 27 to 67 years.

The indication for orbital decompression is progressive exophthalmos in the presence of increasing visual change. Subjectively, protrusion of the eyeballs, diminished, blurred or double vision and also a sensitiveness to light and excessive lacrimation may be noted. Objectively, there is swelling of the eyelids, chemosis and at times keratinization of the conjunctiva. External ocular muscle palsies are noted in most instances. The power of convergence is frequently impaired. Limitation of movement of one or both eyeballs in one or all phases may be seen. In our group of cases the upward gaze was considerably limited. In one instance there was complete ophthalmoplegia bilaterally. In 6 patients considerable care had to be exerted to keep the eyelids partially closed so that they would not retract behind the eyeball. Corneal ulceration, recent or old, was present in several patients. The wedge shaped areas of discoloration of the conjunctiva in the medial and lateral portions of the eyeballs are indications of exposure and usually mean the patient's eyelids do not close completely at any time.

Revision of article originally published in the Journal of Clinical Endocrinology, 10.1231–1236 (Oct.) 1950.

These progressive symptoms should seriously concern all of those who come in contact with these patients. Exophthalmos that is progressive should be observed closely by the internist, ophthalmologist and the neurosurgeon so as to determine the course of treatment and, if surgery is indicated, to decide the optimum time. This, naturally is variable and will depend to some extent on the individual's previous experiences and observations. It is reasonable to state that in the presence of severe, progressive exophthalmos associated with changes in vision in a patient without thyroid toxic symptoms with a normal or subnormal basal metabolic rate, orbital decompression is indicated. The increase in retro-orbital resistance to pressure on the eyeball with the palpating finger is an important finding. In none of the patients subjected to orbital decompression was the retro-orbital resistance normal. Patients with marked exophthalmos with little or no increase in retro-orbital resistance usually are in no danger of losing their eyeballs unless the exophthalmos is so great that corneal ulcerations occur or that atrophy is taking place in the optic nerve.

The measurement of exophthalmos by the grading system is valueless unless the grading is done by one individual. False impressions are easily obtained due to the puffiness of the eyelids or variable degrees of conjunctival edema. The exophthalmometer in experienced hands is of utmost value for noting accurately the degree of exophthalmos. It is true that in a few instances the degree of exophthalmos may be less marked in a patient with a fulminating so-called malignant exophthalmos than in a patient whose eyeballs are not in jeopardy.

In the 79 patients, the preoperative maximum degree of exophthalmos was 37 mm. and the minimum 19 mm. In 10 of the 79 patients the protrusion was 25 mm. or more. In only 8 patients were the measurements exactly the same for each eye. The others varied up to 6 mm. The progressive stage of exophthalmos appeared in two weeks to twenty-five years following thyroidectomy, although some degree of exophthalmos was usually present at the time of thyroidectomy. *The average length of time between the thyroid operation and the orbital decompression was four years.* In 2 patients x-ray treatment for hyperthyroidism had been successfully carried out elsewhere ten years and two months respectively, before orbital decompression had become necessary. Marked progressive exophthalmos causing visual changes necessitated orbital decompression in 2 patients one month and four months respectively, before thyroidectomy became necessary for the hyperthyroidism. These patients had low metabolic rates and no evidence of hyperthyroidism other than progressive exophthalmos at the time of the orbital decompression.

There appeared to be no relationship between the rapidity of the development of exophthalmos and extra-ocular muscle palsy. The muscle palsies occurred more frequently in patients with a moderate degree of exophthalmos than in those with severe protrusion of the eyeballs. It is in these patients that a brawny-like edema takes place in the retro-orbital tissues, and in most instances at the time of orbital decompression there is very little fatty tissue, the intra-orbital space being occupied by pale, firm, greatly enlarged orbital muscles.

The basal metabolic rates in most instances were below normal, being as low as minus 20 per cent in 6 patients. In only 4 patients was the basal metabolic rate above normal.

The differential diagnosis of progressive exophthalmos is usually not difficult except in instances in which one eye is primarily affected. In these individuals, orbital tumors, an infectious process, cavernous sinus thrombosis, congenital malformations and arteriovenous aneurysms must be considered. However, the high incidence of extra-ocular muscle palsies in patients with exophthalmos due to thyroid disease is of definite help in making the diagnosis.

Before orbital decompression is actually decided on, conservative measures should be instituted, such as limitation of fluid intake, reduction in weight whenever the patient is obese, and administration of desiccated thyroid when generalized myxedema is obvious. Procrastination of operation should not be tolerated when visual loss is detected and if all palliative therapy has been of no



Fig. 27. Photographs of a skull demonstrating the actual area of bone that is removed in a modified extensive orbital decompression for progressive exophthalmos, *a*, small triangular bone flap; *b*, line of fracture of bone flap, *c*, bone to be removed; *d*, superior orbital fissure. The burr openings made for elevation of the triangular bone flap are filled with a small tantalum plate or segment of bone so as to prevent deformity.

benefit. Orbital decompression for cosmetic effect should not be encouraged unless that patient's livelihood depends on his or her appearance.

The surgical technic used remains essentially the same as described by Naffziger[2, 5, 6, 7] in his original and subsequent papers, with certain modifications together with a few preoperative and postoperative suggestions which we have found helpful.

It has been our custom to suture the eyelids temporarily with interrupted mattress sutures of black silk, just before the decompression. This is done immediately following the induction of anesthesia. It not only improves the operative result but reduces to a minimum the postoperative conjunctival edema and safeguards against formation of corneal ulcers.

A modified coronal incision is made with the scalp flap being reflected to the supra-orbital ridges. A small triangular bone flap is made in each frontal region, the bony openings being made with a small trephine electric drill; this permits replacement of the bone buttons at the completion of the operation and prevents bony deformity as a result of the operation. The dura is separated from the orbital plate, and the temporal muscle is separated from the lateral margins of the orbit. The roof of the orbit, the sphenoid wing, the lateral margin of the orbit to the inferior orbital fissure as well as the roof of the optic canal are removed

(Fig. 27). Whenever large frontal ethmoid or frontal sinuses are present, they are opened and the mucous membrane is gently peeled from the walls of the sinus, if not large, the mucous membrane is left intact. If an opening is made in the membrane the folds will fall together. These membranes are then sealed with gelfoam impregnated with one of the sulfa powders. The inferior wall of the frontal sinus is removed only in the large extensions, where adequate decompression cannot be obtained in any other manner. Many times more adequate decompressian can be obtained by removing the inferior portion of the orbital rim superiorly. The peri-orbital fascia is then incised and may be utilized as an added protection to cover an opened sinus with a pedicle flap of the fascia. The extra-ocular muscles and fatty tissue will bulge through the opening made in the peri-orbital fascia (Fig. 28). We have not felt it necessary to obtain muscle

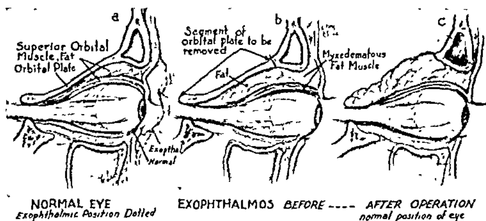


Fig 28. Sagittal section of the orbit and its contents with the eye in the normal position, and also the varying degrees of exophthalmos, which are shown in relief. *b*, Exophthalmos before operation and segment of bone to be removed. *c*, Recession of orbit and protrusion of fat and soft tissue through area from which the bone has been removed.

biopsy specimens in any of our recent cases, as the microscopic sections demonstrate fragmentation and edema of the individual muscles in all patients It has also been my impression that extra-ocular muscle palsies may possibly be increased by taking a biopsy specimen. Certainly, we have been cautious not to incise the annulus of Zinn, since this definitely will increase or produce extra-ocular muscle palsy. A small catheter is used on each side, both for drainage and for instilling penicillin postoperatively if the sinuses have been opened. The scalp flap is replaced and closed with through-and-through interrupted black silk sutures.

Upon removal of the drapes at the completion of the operation, the eyes show immediate marked recession, and some pulsation is noted. The eyelids which have been previously sutured are covered with boric strips and a rubber bag (condom) partially filled with air is placed over each eye and kept in place with Ace bandages. This allows firm pressure over the eyes which is relatively comfortable for the patient and also will prevent ischemia from too tight pressure.

When orbital decompression was first suggested it was performed unilaterally even if both eyes were involved. *Bilateral decompression can be done simultaneously* by two surgeons in a relatively short time, taking an hour and a half to two

hours to complete the operation. We believe that the bilateral procedure is indicated in all cases associated with hyperthyroidism, since in most patients both eyes are involved eventually. Complete radical decompression is necessary to produce the desired results (Fig. 29).

The immediate postoperative reduction in the exophthalmos is always dramatic. It is important that firm pressure be kept over both eyes, since any swelling that takes place will occur in the tissues behind the orbital rim, rather than anteriorly. For that reason it is necessary that the pressure remain constant for the first seven days following the operation; the pressure is released daily during the period while the wound is being dressed. Many weeks and months of chemosis are avoided in that way and the improvement has remained more satisfactory than before the use of constant pressure on the orbits.

There has been no operative mortality. The postoperative complications have been transient. With the more radical decompression, both the cosmetic and visual results have improved. Long standing extra-ocular muscle palsies have



Fig. 29. *a*, Before orbital decompression and *b*, three months after operation.

been slow to recover and have been permanent in 8 patients. Diplopia has not been a factor after one year following operation even in patients with extra-ocular muscle palsies, since the patients learn to ignore one image. In the first patient subjected to orbital decompression in 1933 with exophthalmos marked in one eye, a small decompression was carried out unilaterally because of large paranasal sinuses. Several months later the other eye became markedly involved. The patient refused further surgery. Corneal ulceration resulted in panophthalmitis, meningitis and death. In 3 patients frontal lobe signs developed following operation; these occurred in the earlier cases in which large frontal flaps were turned down, permitting more pressure on the frontal lobes. It is fair to say, however, that in one of these patients following thyroidectomy a psychosis developed of such a degree that it was necessary to send him to a psychopathic hospital for management; he recovered spontaneously. Following the use of a smaller bone flap we have not noted frontal lobe signs as a result of swelling of the frontal lobes in any of the patients.

In all patients subjected to orbital decompression the eyeballs were saved and the vision improved. In 2 patients, before the days of chemotherapy, incomplete decompressions were carried out, making it necessary for the otolaryngologist to exenterate the maxillary, ethmoid and frontal sinuses to allow a satisfactory decompression.

The amount of recession is usually in direct proportion to the degree of

exophthalmos and, therefore, one cannot give the average reduction of exophthalmos in a group of patients except perhaps to give the maximum reduction, which was 10 mm., and the minimum, 4 mm. Gradual recession in the exophthalmos has continued in patients over a period of years.

There is an opitmum time for orbital decompression. Operation should not be withheld until severe chemosis and perhaps corneal ulceration have developed. Indications for the procedure are progressive exophthalmos of a high degree and progressive visual changes.

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CHRONIC THYROIDITIS

SAMUEL F. MARSHALL, WILLIAM A. MEISSNER AND DELBERT C. SMITH

Chronic thyroiditis, as evidenced by degeneration and fibrotic changes in the thyroid gland, is not a common disease entity but is encountered fairly frequently by the clinician and surgeon experienced in thyroid disease. The recognition of this pathologic process in the thyroid gland is important from the clinical aspect because its firmness, adherence and increase in size of the gland may cause it to be mistaken for malignant neoplasm arising in the thyroid gland.

Classification of this type of thyroid disease has always been more or less troublesome, and loosely used and poorly defined terminology has contributed in no small way to the confusion and disagreement regarding thyroiditis.

More than half a century has passed since Bernhard Riedel,[1] a German surgeon in Jena (1896), presented his original report on the condition of the thyroid gland that has since retained his name and has come to be known as Riedel's struma. Sixteen years later, Hashimoto[2] reported what he considered to be a distinctly separate clinical and pathologic entity, struma lymphomatosa. Since these original reports, many articles have appeared in the literature concerning chronic thyroiditis, but little has been added to the knowledge of its etiology. Likewise, the clinical and pathologic picture, as known today, has changed little from the original descriptions.

Riedel[1] pointed out in his first report of 2 cases that the gland was of woody hardness and densely adherent to the trachea and surrounding blood vessels and nerves, all of which made it difficult to distinguish from a malignant lesion.

Hashimoto's[2] original report consisted of 4 cases, all in women over forty years of age, who presented essentially the clinical picture as it is known today. He was aware of the absence of inflammatory reaction and the lack of ad herence to surrounding structures. He went further to point out the postopera tive picture of myxedema, which disappeared after the internal administration of thyroid substance. The chief pathologic findings described were diffuse lymphocytic infiltration, atrophy of the acinar epithelium, with absence of colloid, and proliferation of connective tissue.

Despite the clarity with which these authors described two distinctly separate clinical entities, much confusion has occurred. This has been the result of the many variants in the microscopical picture as well as in the clinical findings. The purpose of this paper is not to give a historical review of the numerous controversies existing over the years or of the literature, but to present a summary of a pathological and clinical study of a group of cases encountered in which operation was performed at the Lahey Clinic during the period of 1928 to 1946, inclusive. As every surgeon knows, these cases may present some perplexing problems in technic at the operating table. The present study was undertaken

Originally published in New England Journal of Medicine, 238.758–766 (May 27), 1943.

with the hope that certain conclusions could be reached from the observation of a fairly large series of cases that would be of value in the diagnosis and further management of these patients.

During the eighteen-year period under consideration 187 cases of undoubted chronic thyroiditis were encountered in the pathological examination of the specimens from approximately 25,000 patients requiring thyroidectomy. There were many other cases in which a tentative diagnosis of thyroiditis was made on the excised tissue, but since a careful pathological review and reclassification of these specimens revealed them to be lacking in many of the characteristics thought necessary to establish this diagnosis, they were discarded in the study of this material. Also, no cases of thyroiditis occurring in hyperplastic goiter, adenomatous goiter or thyroid tumor are included, although the condition may complicate such already diseased glands. It is evident that this condition is by no means rare, since this represents an incidence of 0.75 per cent. These 187 cases, selected after careful correlation of the clinical findings with the microscopical *picture, form the basis of our report.*

Many other cases were found in which a clinical diagnosis of thyroiditis was made, but these patients were not submitted to operation, so that pathological examination could not confirm the accuracy of this diagnosis and, of course, they cannot be included in this study. There can be no doubt that with sufficient experience in the disease a fairly large number of cases can be recognized clinically and that, in the event of no complications, operation can safely be avoided. Because of enlargement of the thyroid gland, development of pressure symptoms, constriction of the trachea or inability definitely to exclude cancer, however, a certain number of patients must submit to operation either to decompress the trachea or to rule out malignant degeneration. Some of these patients came to surgery with enlarged thyroid glands that were mistakenly construed by the clinician to be adenomatous goiter. A correct preoperative diagnosis of thyroiditis in the group of 187 cases was made in only 44 patients, or 23.5 per cent, so that the preoperative error in diagnosis of patients submitted to operation is considerable. It is also well to emphasize the fact that the uncertainty regarding the type *of thyroid disease present necessitates biopsy or resection of the thyroid gland,* and this very fact accounts for the low percentage of correct preoperative diagnosis in this group of operated cases. In many cases the pathologist has difficulty diagnosing the condition correctly without microscopical study. Dr. Frank H Lahey has often described the characteristics that enable thyroiditis to be recognized clinically in a large number of cases, but the necessity for repeated periodic examinations has also been constantly emphasized. Operation is demanded when even the slightest suspicion of a malignant lesion exists, and progressive enlargement or constrictive symptoms occurring in a previously clinically recognized thyroiditis may also require surgical interference at some time after the initial diagnosis has been established.

PATHOLOGY

Concerning the pathology of the various forms of thyroiditis it should be pointed out that there are apparently several ways in which the gland may react

to injury or irritation. These basic types of reaction are seen whether the injury is the result of actual infection, trauma, vascular disturbances or altered physiology. Either the stroma or the epithelium of the thyroid gland may show considerable change in response to irritation or injury. The stromal changes consist of fibrosis and infiltration with inflammatory cells, of either mononuclear or polymorphonuclear type. The epithelial changes consist of diminution in the size or atrophy of the acini, acidophilia of the thyroid cells to become the Hürthle type and occasionally epidermidization of the epithelium. At times colloid is allowed to spill out of the follicle into the stroma; since colloid is an irritant, it causes an inflammatory response, with a foreign-body, giant-cell reaction, when it is free in the stroma.

Examples of such changes are seen in the pathologic states of hyperplasia, adenomatous goiter and tumor. In hyperplasia there is frequently an infiltration with lymphocytes and often the formation of secondary lymph follicles. A small amount of fibrosis often accompanies the lymphoid infiltration, particularly in the later stages of involution. The so-called "exhaustion atrophy" of the thyroid gland is a state that presumably follows overactivity, and in this condition there is not only infiltration with lymphocytes and some fibrosis but also frequently an acidophilia of the epithelium.

In adenomatous goiter, fibrosis of the gland owing to hemorrhage or colloid spillage is frequent. Not uncommonly lymphoid infiltration and compression of the acini adjacent to the capsule of the tumor are found in adenomas. In malignant tumors there is, of course, the inflammatory exudate frequent in cancers.

At times the thyroid gland is the site of similar basic inflammatory changes, which apparently are not associated with hyperplasia, adenomatous goiter or tumor. It is this group, called chronic thyroiditis, with which the present study is involved, cases that showed a definitive type of pathologic change in addition *to inflammation were not included.*

Excellent discussions and reviews of the pathology of chronic thyroiditis can be found in detail in the papers of Womack,[3] McClintock and Wright,[4] Joll[5] and others,[6, 7] and a lengthy description is unnecessary here. For the purposes of clinical comparison, it was found that cases of chronic thyroiditis could easily be segregated into three main groups, which were reasonably distinct both pathologically and clinically. The great majority of cases fall fairly easily into one of the three categories. The more important characteristics of each group are described below.

Group I

This group consisted of 41 cases showing a reaction that seemed to be due obviously to infection. It is well known that acute infections of the thyroid gland occur, but since such a gland is not removed surgically in the acute stage of an infection, no acute infections were present in this series. A group of 18 glands, however, showed changes that may be called subacute inflammation (Fig. 30); there was a moderate degree of fibrosis with numerous inflammatory cells, chiefly polymorphonuclear neutrophils often centered in acini. Such acini usually showed degeneration and spillage of colloid with foreign-body, giant-cell

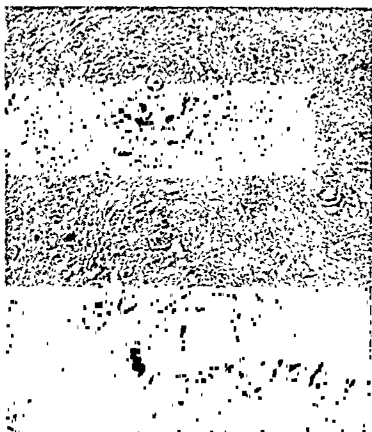


Fig. 30. Infection of the thyroid gland in the subacute stage in a 46 year old man who complained of pain and swelling in the thyroid region of five weeks' duration. Note the numerous polymorphonuclear neutrophils in the stroma and in the large acinus at the lower right Fibrosis and foreign-body giant cells (hematoxylin and eosin, × 50).

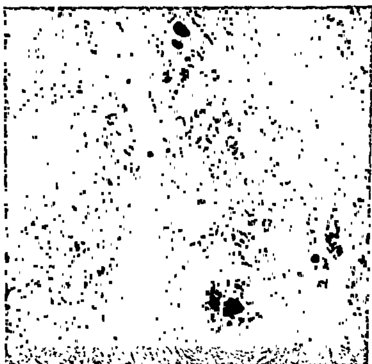


Fig 31. Infection of the thyroid gland in the chronic stage in a 37 year old woman who had soreness and enlargement in the neck for four weeks and a tonsillectomy for chronic tonsillitis one year previously. Note the numerous foreign-body giant cells (hematoxylin and eosin, × 50).

response, although the latter cells were not numerous in this stage. In the chronic stage of the infection represented by 18 other specimens (Fig. 31), the polymorphonuclear leukocytes had largely or completely disappeared, but numerous foreign-body giant cells were still present reacting to colloid. Also scattered throughout the fibrotic stroma were numerous lymphocytes and plasma cells. The fibrotic stage of the infection apparently represents the healed stage (Fig. 32), and in this terminal phase foreign-body giant cells were usually absent and other inflammatory cells few in number—it is this stage that usually has been designated as Riedel's struma. In none of the stages in this group was the epithelial change characteristic, and although considerable epithelium was ap-

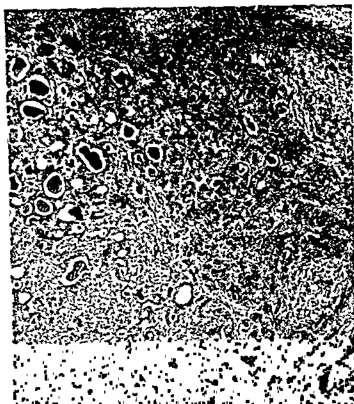


Fig. 32. Infection of the thyroid gland, largely healed, in a 52 year old woman who had had swelling in the neck, with difficulty in breathing, for four years and with restricted breathing on raising the arms while combing hair. Note the marked fibrosis. Many of the remaining acini are little changed (hematoxylin and eosin, × 50).

parently destroyed and replaced by the infection and subsequent fibrosis, that which remained usually showed little or no change and no evident atrophy. Acidophilia was absent or slight; there was occasional epidermidization. Grossly, the glands in this group were all firm, fibrotic and often gray or white. The capsules in most specimens were adherent both to the thyroid gland and presumably to the adjacent structures, since they were infiltrated microscopically with the inflammatory process. The change in the gland was sometimes focal, but often diffuse.

Group II

The second group was composed of 78 thyroid glands, which were generally designated as Hashimoto's struma or struma lymphomatosa. This group patho-



Fig 33. Struma lymphomatosa in a 47 year old woman who had had goiter for three years, increasing in size for the past year, with occasional coughing and choking spells and with difficulty in breathing on exertion. Note the characteristic, marked lymphoid infiltration and atrophy of epithelium (hematoxylin and eosin, × 50).

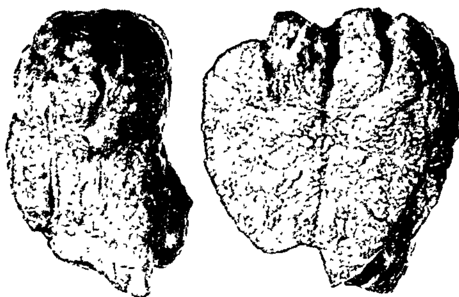


Fig. 34. Struma lymphomatosa in a 61 year old woman who complained of marked swelling in the neck of one year's duration. Note the lobulation and the thin capsule.

logically showed a marked infiltration of the stroma with lymphoid cells and the formation of numerous secondary lymph follicles (Fig. 33). The lymphoid infiltration in these glands was often little more than that seen in many cases of primary hyperthyroidism, and such a marked lymphoid infiltrate is not sufficient evidence in itself to warrant placing the gland in this general group. The specimens, in addition to the lymphoid infiltration, uniformly showed atrophy and marked acidophilia of the epithelium. Occasionally there was some degeneration of colloid with foreign-body giant-cell reaction, but this was inconstant. Although the stroma always showed at least a small amount of fibrosis, in small strands and cords, the fibrosis was in broader bands only when pronounced, as in the first group. Grossly the specimens in this category averaged about 100 gm. in weight for the two lobes (Fig. 34). They had a rubbery consistence. The change was diffuse and homogeneous throughout both lobes. The capsules were grossly preserved with no suggestion of adherence.

Group III

This was a conglomerate group and undoubtedly included thyroiditis resulting from several causes. The specimens showed little that was characteristic grossly. Microscopically, they showed the basic stromal (slight fibrosis and round-cell infiltration and occasionally spilled colloid) and epithelial (absent or mild acidophilia and atrophy) changes common to all injuries of the thyroid gland, but the changes were of such a mild degree that a further classification was not possible. It seemed best to designate this group of 68 cases as simply "chronic thyroiditis, nonspecific." Two cases of thyroiditis presumably due to irradiation and 1 case of probable syphilis of the thyroid gland were not included. There were no examples of tuberculosis of the gland. Some of the thyroid glands in this group appeared similar to the "exhaustion atrophy" state, although a history of previous hyperthyroidism was unusual. Other glands suggested that the inflammatory response was the result of a mild infection, which was not severe enough to warrant inclusion in Group I. Still other specimens must have represented an early stage of struma lymphomatosa, but with changes too mild to be pathognomonic. Vascular changes were considered a possibility as an etiologic factor in this group, but no changes could be found that could be directly attributed to vascular lesions. Still another etiologic possibility is trauma.

It is possible, then, to divide chronic thyroiditis into three groups pathologically. Group I includes cases of thyroiditis in the true sense—that is, inflammation of the thyroid gland caused by actual infection. The terminal or healed stage of this type of thyroiditis has been known as Riedel's struma, but it seems more logical to include all stages of infection of the thyroid gland under one grouping no matter whether the infection is acute, subacute, chronic or healed. Group II, composed of specimens that have previously been designated as struma lymphomatosa, appears to be distinct and separate from thyroiditis caused by infection. The pathological changes are characteristic enough in most cases to warrant a separation of these specimens from the other types of thyroiditis, although the etiology is unknown. In addition to these two groups, which present more or less specific pictures pathologically, there is the third group of rather

Table 2. Data in Cases of Thyroiditis Due to Infection (Group I)

STAGE OF THYROIDITIS	NO. OF CASES	AGE OF PATIENTS			SEX OF PATIENTS		AVERAGE DURATION OF SYMPTOMS	CORRECT PRE-OPERATIVE DIAGNOSIS	CASES OF PRE-OPERATIVE HYPOTHYROIDISM	CASES OF POST-OPERATIVE HYPOTHYROIDISM	CASES OF POSTOPERATIVE COMPLICATIONS		
		Youngest	Oldest	Average	Male	Female					Tracheotomy	Tetany	Recurrent Laryngeal Nerve Paralysis
		yr.	*yr.*	*yr.*			*mo.*	%	%	%			
Subacute	18	36	53	44	4	14	2.2	55	—	11	—	—	1
Chronic	16	29	70	46	6	10	6.0	63	6	37	—	—	—
Healed	7	26	63	49	1	6	23.0	43	29	57	—	1	—
Totals	41				11	30					—	1	1
Averages		26	70	46			9.6	56	7	27			

Table 3. Data in Cases of Struma Lymphomatosa (Group II)

DEGREE OF THYROIDITIS	NO OF CASES	AGE OF PATIENTS			SEX OF PATIENTS		AVERAGE DURATION OF SYMPTOMS	CORRECT PRE-OPERATIVE DIAGNOSIS	CASES OF PRE-OPERATIVE HYPOTHYROIDISM	CASES OF POST-OPERATIVE HYPOTHYROIDISM	CASES OF POSTOPERATIVE COMPLICATIONS		
		Youngest	Oldest	Average	Male	Female					Tracheotomy	Tetany	Recurrent Laryngeal Nerve Paralysis
		yr.	*yr*	*yr.*			*mo.*	%	%	%			
Mild	12	29	58	45	—	12	23	—	—	50	—	1	—
Moderate	36	31	71	52	—	36	24	14	11	77	1	—	2
Marked	30	33	69	51	1	29	28	27	7	93	1	1	3
Totals	78				1	77					2	2	5
Averages		29	71	50			26	17	8	79			

*Table 4. Data in Cases of Nonspecific Thyroiditis (Group III)**

NO. OF CASES	AGE OF PATIENTS			SEX OF PATIENTS		AVERAGE DURATION OF SYMPTOMS	CORRECT PREOPERATIVE DIAGNOSIS	CASES OF PREOPERATIVE HYPOTHYROIDISM	CASES OF POSTOPERATIVE HYPOTHYROIDISM
	Youngest	Oldest	Average	Male	Female				
	yr	*yr.*	*yr.*			*mo.*	%	%	%
68	12	75	43	3	65	22	12	6	50

* No postoperative complications occurred in this group of cases.

of the trachea and to exclude the possibility of overlooking malignant tumors. If treatment is indicated in any case, we believe that operation offers the best method. It should consist of either partial resection of the gland or excision of the isthmus to relieve constriction of the trachea. We have not treated any of these patients with irradiation although there are some reports of good results in the literature. We believe that additional fibrosis produced by the reaction of irradiation may well increase the constriction on the trachea and also further destroy remaining thyroid-secreting epithelium. The principal indications for surgery are definite pathologic evidence that the process is not malignant and relief of pressure symptoms or release of tracheal constriction. In most cases of

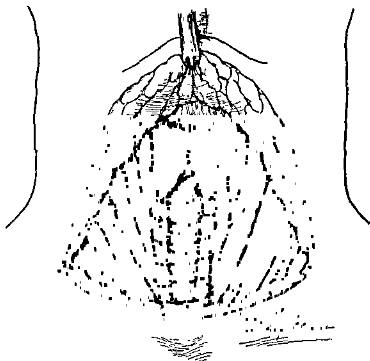


Fig 35. Stage in operation for chronic thyroiditis. The isthmus and medial portions of both lobes have been removed to clear the anterior part of the trachea of all thyroid tissue. The sternohyoid muscles have been sutured to the trachea to prevent adherence of the lateral lobes and recurrence of compression.

Riedel's thyroiditis the diagnosis can be established at the operating table by the appearance of the thyroid gland upon exposure and by its adherence to surrounding structures, and biopsy can immediately confirm this. Radical resection is unnecessary, and may be difficult because of the stony hardness of the gland and the difficulty in dissection and exposure of the normal structures such as the recurrent laryngeal nerves and parathyroid glands. If radical removal is persisted in when marked induration and adherence are present, serious complications may result from injury to the parathyroid glands and to the recurrent laryngeal nerves. Furthermore, release of pressure on the trachea can be obtained by simple removal of the thyroid isthmus, as proposed by Lahey,[6] which separates the lobes and releases the vise-like pressure on the trachea. Suture of the prethyroid muscles to the tracheal fascia prevents the lobes from becoming adherent to each other with return of pressure on the trachea (Fig. 35). Inasmuch as active thy-

roid-secreting epithelium is still present in the sclerosed gland in Riedel's thyroiditis, extensive partial removal is undesirable, since this procedure decreases thyroxin secretion still more and increases the number of cases in which myxedema develops.

Bilateral partial thyroidectomy is advisable in Hashimoto's struma and should be radical enough to relieve the compression (Fig. 36) noted in these cases as well as to improve the cosmetic effect by removal of an enlarged gland. Large remnants of either lobe should be allowed to remain to avoid injury to the recurrent laryngeal nerves or parathyroid glands, although the lack of adherence of the gland precludes much risk. It is evident that a radical resection in these cases will result in earlier signs of myxedema, but many of these patients exhibit



Fig. 36. Narrowing of the trachea caused by compression from chronic thyroiditis. (Reprinted from Lahey[6] by permission of the publishers.)

hypothyroidism before operation; most patients (7 per cent preoperatively and 27 per cent postoperatively in Group I, 8 per cent preoperatively and 79 per cent postoperatively in Group II, and 6 per cent preoperatively and 50 per cent postoperatively in Group III) develop myxedema later regardless of how much thyroid tissue is removed. It matters only that sufficient tissue be removed to relieve pressure symptoms and constriction of the trachea; we believe that this can be done best by a liberal partial thyroidectomy.

TYPE OF OPERATION

From this discussion, excision of the thyroid isthmus is considered sufficient in most cases of infection thyroiditis, and a partial bilateral thyroidectomy is desirable in struma lymphomatosa. The best procedure in patients in Group III is excision of the isthmus, but this may have to be modified if sufficient relief of pressure cannot be obtained by such a conservative procedure. In these cases, as in Group I, every effort should be made to conserve thyroid tissue to avoid myxedema. The frequency of myxedema in the various groups after the various operative methods may well serve as a guide in planning treatment in these cases.

Thyroid deficiency is present or develops after operation in many cases. It is much less common in the infectious type (27 per cent), but in the more advanced stage of this group (Riedel) it was noted in 57 per cent. As stated above, patients with Hashimoto's struma developed signs of thyroid deficiency in 79 per cent of the whole group, but this incidence was increased only 8 per cent if partial thyroidectomy was done. In the nonspecific group, thyroid deficiency was noted in 50 per cent of cases, but a decreased tendency (33 per cent) was noted with resection of the isthmus only. In some instances too few cases were observed to draw final and definite conclusions, but our studies seem to point to the value of conserving thyroid tissue whenever possible, except possibly in the Hashimoto type.

Postoperative complications consisted of tetany and recurrent-laryngeal-nerve paralysis (Tables 2, 3 and 4); 2 patients required temporary tracheotomy after operation for Hashimoto's struma, but this was necessary because of edema arising after operation in myxedematous patients, which is not an uncommon complication and did not follow nerve injury. In view of the possible tendency for patients with myxedema to develop postoperative edema it is wise to correct any thyroid deficiency by oral administration of desiccated thyroid before operation and thus to avoid respiratory difficulty after operation. We believe that with recognition of the necessity for exposure of the recurrent nerves in all partial resections of the thyroid gland for any cause, the complication of recurrent-laryngeal-nerve paralysis can be avoided or at least seldom encountered.

SUMMARY

A report of 187 cases of chronic thyroiditis is presented, and an attempt is made to analyze the clinical and pathological characteristics.

Chronic thyroiditis occurred not infrequently in our experiences with approximately 25,000 operations for thyroid disease, an incidence of 0.75 per cent.

An attempt is made to classify these cases into three groups on the basis of pathological changes noted in the excised gland and to correlate these findings with the clinical course of the patients.

Clinical diagnosis of chronic thyroiditis is possible, and it is clinically possible to distinguish thyroiditis from thyroid cancer in a large number of cases.

Treatment is unnecessary in many cases but when necessary to establish diagnosis or to relieve pressure on the trachea, surgical removal of the isthmus or partial thyroidectomy offers the best method.

Myxedema develops with the course of the disease, and operation should be planned to minimize this tendency as much as possible.

Operative complications can be avoided or decreased with a better selection of the type of operation in each case and with improvement in technic of thyroid resection.

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MALIGNANCY IN ADENOMAS OF THE THYROID

FRANK H. LAHEY AND HUGH F. HARE

Except for the rare case of the microscopic diagnosis of carcinoma in hyperplastic thyroid glands, it is now quite generally accepted that the origin of cancer of the thyroid is, for practical purposes, in the preexisting adenoma of the gland. While this premise has been repeatedly promoted by us and by many others, there is still a great variation in the reported percentage incidence of malignant disease in the various types of adenomatous goiter, and there is even mild disagreement by some that the incidence of malignant degeneration in adenomatous goiter is such as to make it worth while for a patient or a physician to concern himself with it.

We should particularly like to give credit to Dr. Allen Graham for his interest and persistence in clarifying and promoting the above thesis. His work in connection with malignancy in adenoma of the thyroid has been of inestimable value to everyone who has dealt with this problem and will, we hope, remain a monument to his name.

There are many reasons for the confusion, disagreements and variations in opinions which have been stated and published regarding the problem of the danger of malignancy in adenomas of the thyroid. Consider only the variations in the difficulties of separating discrete adenomas from multiple adenomas of the thyroid in various parts of the country. In our part of the country, along the eastern seaboard, where endemic goiter is not known and multiple adenomatous goiter is uncommon in the native population, the majority of the thyroid tumors will be the discrete, fetal or embryonal adenomas that are true tumors of the thyroid gland. If one lives in a region where multiple colloid adenomatous goiter, really a degenerative disease of the thyroid, is the commoner, the problem will be an extremely complicated one, since a true fetal or embryonal adenoma may be so included in the multiple nodules of this type of thyroid enlargement that it will be impossible to distinguish one type of nodular enlargement of the thyroid from the other.

It has not been easy to convince many internists of the danger of malignant change that exists in adenomatous goiter. This has been understandable in some measure because, in the past, reports on the incidence of malignancy in adenomas of the thyroid were not infrequently made on a general basis, in which were included all types of nodular goiter, rather than on the separation of the discrete from the multiple adenomas. This separation is of extreme importance, as we shall show by our figures, in the series of cases reported in this paper of the various types of adenoma and the percentage of malignant growths among them.

Originally published in Journal of the American Medical Association, *145*:689–695 (Mar. 10) 1951.

CLASSIFICATION

Grade I

Papillary cystadenoma with invasion
Alveolar adenoma with invasion

Grade II

Papillary adenocarcinoma
Alveolar adenocarcinoma

Grade III

Small cell
Compact
Diffuse
Giant cell
Hurthle cell
Fibrosarcoma

Another difficulty in convincing many physicians of the real hazards of malignancy, particularly in discrete adenomas of the thyroid, is due to the fact that, especially if the patients live in a region where goiter is not prevalent, physicians have not had the opportunity to see large numbers of patients with malignant thyroid tumors. Therefore, as the result of such a limited experience with these states, they establish a false sense of confidence in the low incidence of malignancy in the type of adenomatous goiter that they have seen. Physicians are often further confused in their impressions of the danger of malignancy in adenomas

Table 1. Histologically Verified Cancer in Thyroid Nodules

	NO. OF PATIENTS	MALIGNANT TUMORS	
		No.	%
Single nodule	1,971	198	10 04
Multiple nodules	1,782	11	0.62
Toxic nodules	440	3	0.68
Toxic multiple nodules	735	4	0.54

in their patients by not having accurately differentiated between true tumors of the thyroid gland, the discrete adenomas, and the false tumors, the multiple adenomatous goiters (the variation in the percentages of malignancy in the different types is shown in Table 1).

Published reports of the incidence of malignancy taken from the autopsy records of any of the general hospitals on the New England seaboard would be sure to create a false impression of the true incidence of malignancy in adenomatous goiter. There is but a limited number of goiters in a community such as this. Much of the pathological study in the past was done in such cases by pathologists who were not particularly interested in or experienced with some of the confusing microscopic discriminations as to what is and what is not frank or potential malignancy of the thyroid, and much of the material was put in an undifferen-

tiated group of cases called adenomatous goiter, in which the discrete adenoma is not separated from multiple adenomas.

In addition to the above difficulty, one reads in the literature of the incidence of malignancy ranging from low to unbelievably high percentages, explained perhaps by the different types of goiter in the different areas, but at times with such wide differences in percentage figures as to make it impossible for us, with our large experience with goiter, to explain the variations. All these factors have done much to confuse a state which is an important one, one in which it is possible to establish relationships and to deal almost without risk with the lesion while it is precancerous.

To establish for the benefit of those who have not been deeply interested in thyroid disease and in order to show the importance of differentiation, one has only to look at Table 1, in which in a series of 1,971 consecutive discrete adenomas the incidence of malignancy is shown to be 10.04 per cent, while in a series of 1,782 multiple adenomatous goiters the incidence of malignancy is shown to be 0.62 per cent.

We wish particularly to call attention to the fact that Table 1 is important in demonstrating that discrete tumors of the thyroid gland are true tumors, whereas many of the multiple nodular or multiple adenomatous goiters are not true tumors but are, as stated above, in reality degenerative processes related in some regions to iodine deficiencies and in others, where iodine exists in the surface water in adequate amounts, to degenerative processes within the thyroid which are not as yet explained.

The distinguishing features of the discrete adenoma in which there has been such a high incidence of malignant disease in our series reported here are. (1) its proneness to occur as a single tumor, although it occasionally does occur as two or even three or more tumors; (2) the fact that it possesses a definite capsule with a thick wall, which is obviously a true tumor capsule; (3) the fact that the thyroid tissue within this thick-walled, definite capsule exists in varying degrees of differentiation, from solid cell structures with almost complete lack of differentiation up to full and complete differentiation. With the multiple adenomatous goiter this differentiating point does not exist. The latter tumors are multiple, often scattered throughout the gland or scattered throughout one lobe; they often possess capsules which are actually but condensed circumferences of connective tissue, their contents, while often seminecrotic, are not of the undifferentiated type but evidence, even in the presence of degeneration within the adenoma, complete thyroid differentiation. One of the purposes of this paper is to stress and prove that the hazard of malignant degeneration in discrete adenoma of the thyroid gland is not only real but dangerously high (10.04 per cent).

Where patients with thyroid abnormalities are seen in large numbers, as in a clinic such as this one, we have had the opportunity to accumulate data on such a large group of cases of the various types that we believe it is our duty to present these figures to the general medical public, with the hope that there will be more general conviction of this real danger of malignancy in discrete adenomas of the thyroid.

We have operated on many patients for cancer of the rectum or colon, and we have often said that rarely do they come for surgical treatment without having

had, for not inconsiderable periods, clear warnings of what they were probably suffering from. When one realizes that in 70 per cent of the cases of this lesion the diagnosis can be made with the sigmoidoscope, there is cause for complaint about the carelessness with which patients tolerate symptoms which indicate the possible presence of these lesions. The situation today with cancer of the thyroid, arising as it does almost solely in discrete adenomas, is even more disturbing and depressing.

In what field are we so blessed with the possibility of early discovery of the precancerous lesion as in the discrete adenoma of the thyroid? Where do we have the precancerous lesion in the form of a readily palpable nodule, so superficially situated that it can be conveniently and easily diagnosed by palpation? Where do we have an undeniably proved precancerous lesion such as a discrete

Table 2. Known Presence of Thyroid Tumor Before Diagnosis

HISTOLOGICAL TYPE	NO. OF PATIENTS	AVERAGE TIME, YR.
Grade I		
Papillary cystadenoma with invasion	76	7.4
Alveolar adenoma with invasion	60	8.5
Grade II		
Papillary adenocarcinoma	130	4.4
Alveolar adenocarcinoma	48	10.0
Grade III		
Small cell, compact	40	7.4
Small cell, diffuse	29	2.3
Giant cell	29	8.4
Hurthle cell	7	7.3
Fibrosarcoma	9	0.66
Total	428	

adenoma of the thyroid, as demonstrated by this series, in which there is such a high percentage of malignancy? Where do we have a lesion that can be discovered so often while precancerous and so successfully removed with practically no mortality and no morbidity?

It is with the above facts in mind that we have been prompted to report the figures and to stress the need for the earliest possible removal of discrete adenomas of the thyroid gland.

Any doubt as to the soundness of the critical statement made concerning our disturbance over the delay in patients coming to us with cancer arising in adenomatous goiter is amply overcome by the figures in Table 2, in which is shown the period of years over which the adenoma had existed before removal. The excision of these adenomas at any reasonable period during the delay period would have avoided practically all of the deaths, uncertainties and hazards associated with the radical operative measures and irradiation treatment procedures necessary for cancer of the thyroid. It can, in fact, almost be said that if every discrete adenoma of the thyroid could be removed in its earliest stages, we would be able to eliminate almost entirely the occurrence of cancer of the thyroid gland.

If one accepts the premise that we have tried to establish in this paper that the real hazard of cancer of the thyroid is in the discrete adenoma, there arise two obviously related questions: (1) At what size should one remove a discrete adenoma of the thyroid? Is it advisable to remove it when it is first discovered, at say the size of a bean, or should one wait until it has become larger? (2) If discrete adenomas appear in young people, how early should they be removed?

If one agrees with the evidence in this paper and in our experience that discrete adenomas of the thyroid are true tumors, it must be assumed that they will never



Fig. 37. Method of dislocating the larynx out of its bed in order to palpate the lobe of the [illegible] ed [illegible] ow [illegible] on.

disappear, except as they occasionally disappear by descending into the mediastinum They will eventually increase in size, and their continuing existence, in the light of the figures reported here, presents a constant danger of cancerous change in them. It is for this reason that we have said that the smaller the adenoma the greater the reason for its removal. This would mean less time for exposure of the host to the danger of malignant degeneration. In the past we have reported the occurrence of adenocarcinoma in very small discrete adenomas, not over the size of a small grape. In the same way, if a child has a discrete adenoma, and one subscribes to the reasoning and evidence reported in this article, why should one permit such a child to go through any part of his life with such a hazard? This is additionally true when it has been proved in our experience that

the younger the person in whom discrete adenomas occur, with the lesser degrees of differentiation, the higher is the incidence of cancer. For the above reasons we have thought that all discrete adenomas of any size and in patients at any age, once diagnosed, should be removed.

What are some of the diagnostic features of a discrete adenoma of the thyroid as differentiated from the degenerative process of the thyroid called multiple



Fig 38. Method of palpating the dislocated right lobe. Note the index finger behind the right sternocleidomastoid muscle, relaxed by turning the chin to the right. The examining thumb is applied over the thyroid lobe in front as the larynx is dislocated to the right by the thumb of the other hand. When the patient is asked to swallow, the thyroid lobe to be palpated ascends and descends between the index finger and the thumb so that it can be thoroughly palpated for a nodule, the consistency that goes with hyperplasia characteristic of hyperthyroidism or the ligneous type of infiltration characteristic of thyroiditis.

adenomatous goiter? A discrete adenoma of the thyroid is palpable as a single tumor. One must realize that in the palpation of the thyroid gland the procedure shown in Figures 37 and 38, which one of us (F. H. L.) devised and published a number of years ago, is of the utmost importance in the diagnosis, since it is usually possible to determine the presence or absence of even a very small discrete tumor of the thyroid and to differentiate it from multiple adenomas by palpating the thyroid gland through and through with the thumb and forefinger, as seen in Figure 38. If one will visualize the procedure illustrated in Figures 37 and 38, it will be seen that by this plan the thyroid gland can be so manipulated out of its bed by dislocating the larynx laterally and so palpated with one finger

behind the gland and one in front as it ascends and descends with swallowing that the smallest discrete adenoma can usually be plainly demonstrated.

We have often been asked whether in discrete adenomas of the thyroid gland we are able to determine the presence of malignancy by palpation of the thyroid before operation. Except in those patients in whom the cancerous growth has eroded the capsule of the adenoma and invaded the parenchyma of the thyroid,

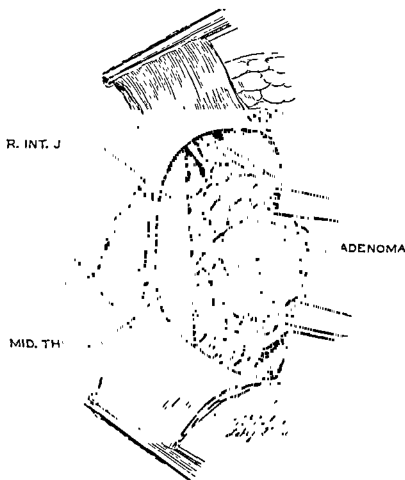


Fig. 39. Semidiagrammatic illustration showing a discrete adenoma within the thyroid Note the method of lifting the thyroid out of its bed, note the middle thyroid vein, which will be ligated between clamps and tied so that the common carotid artery can be exposed, the inferior thyroid artery demonstrated and the recurrent laryngeal nerve found and exposed. It is obvious from this type of adenoma which so completely occupies the lobe that the recurrent laryngeal nerve (Fig. 40, *a*) as it enters the larynx will frequently be in direct contact with the back of the adenoma and, unless exposed, can easily be injured.

thus producing fixation, firmness and loss of outline of the tumor, we have not been able to make this differentiation preoperatively. We are, however, extremely suspicious of any discrete adenoma which is unduly firm and fixed, but we wish to call attention to the fact that we have not infrequently found this firmness and fixation in adenomas of patients who had had old or recent hemorrhage into them. The occurrence of hemorrhage within an adenoma often accounts for the sudden tenderness about which patients complain, but with the gradual disappearance of such tenderness there often remains a high degree of firmness within the tumor, secondary to its overdistention by the hemorrhage

within its capsule, and a considerable degree of fixation as the result of the reaction that occurs in the tissues surrounding the capsule of the adenoma.

The surgical treatment of discrete adenoma of the thyroid, particularly after the above discussion, needs little comment. While it is evident that we believe

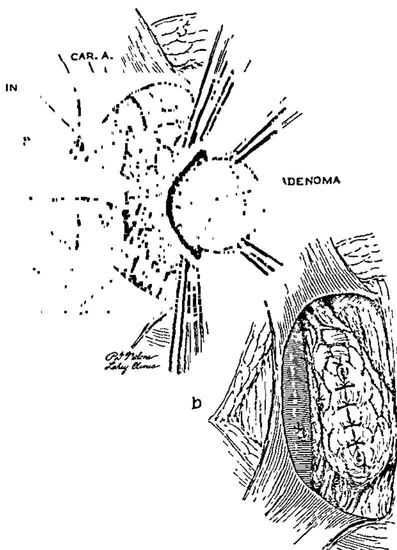


Fig 40. Semidiagrammatic illustration showing the method of excision of a discrete adenoma from a thyroid lobe.

a, Note the exposure of the recurrent laryngeal nerve and the inferior thyroid artery. Notice [illegible] enoma and the two clamps [illegible] g the adenoma is separated [illegible] The thyroid tissue beneath the two clamps above and the two clamps below is then ligated with heavy surgical gut and the bleeders controlled.

b, The envelope of thyroid tissue remaining on either side is brought together to reconstruct the lobe into an almost normal thyroid. This has proved a very satisfactory method over the years for removing discrete adenomas without sacrificing thyroid tissue.

that all discrete adenomas of the thyroid should be removed, we should like to add the comment that they should be removed intact and unruptured.

There will be some differences of opinion as to how discrete adenomas of the thyroid should be removed but none, we are sure, regarding the desirability of

their being removed unruptured because of the fact that one can never be certain whether or not they are malignant until the pathological report is returned, no matter how harmless the discrete adenomas may appear.

As to the methods of removal, there will be minor disagreement as to whether or not the discrete adenoma should be removed as an individual tumor, as much of the lobe of the thyroid on the affected side as possible being left behind, or whether it should be removed by complete lobectomy on the affected side.

While our preference is toward local excision of the discrete tumor to await the final report of the pathologist (Figs. 39 and 40), we have no disagreement with those who would advocate removal of the adenoma by complete lobectomy. We believe that the decision as to whether a radical neck dissection should be done, often based on whether there is blood or lymph vessel invasion, should be made after microscopic examination of paraffin sections. We should not care to make such an important decision after examination of frozen sections. If the report is such as to justify radical neck dissection, we have no hesitancy in doing it at once; if the report is such as not to indicate a radical neck dissection, we have not sacrificed good thyroid tissue. Our feeling is that we must wait until the microscopic criteria are received on which we settle whether or not a radical dissection of the neck should be done, and so we prefer the former course of the removal of the unruptured discrete adenoma, preserving as much as possible of the normal thyroid tissue until the pathologist's report is at hand (Figs. 39 and 40).

In previous communications we have discussed the evidence on which we base the decision for or against radical dissection of the neck on the affected side, and we have not particularly changed it. We believe that radical dissections of the neck are indicated in all cases of carcinomas arising in discrete adenomas which have eroded the capsule of the adenoma and involved the parenchyma of the thyroid on the affected side. We believe that radical dissections of the neck are indicated for all patients with malignant changes in discrete adenomas of the thyroid, even when they have not invaded the capsule of the thyroid, if they are of Grade II or Grade III variety, adenocarcinoma or small cell or giant cell carcinoma. We believe that radical dissections of the neck are indicated even in the presence of early carcinomas within the discrete adenomas if they are Grade II or Grade III, when they have eroded into the lymphatics within the adenomas or when they have eroded into the blood vessels within the adenomas. We believe that radical dissections of the neck are indicated for patients with discrete adenomas with papillary adenocarcinoma without erosion of the capsule but with invasion of blood vessels or lymphatics. We do not believe that radical neck dissections are indicated for patients who have discrete adenomas with papillary adenocarcinoma when there is no erosion of the capsule or no invasion of the blood vessels or of the lymphatics within the adenoma.

When any of the above conditions has occurred, a radical dissection in our experience has consisted of complete removal of the internal jugular vein from beneath the angle of the jaw to the clavicle, with complete dissection of all the node-bearing area of the neck and with complete removal of the thyroid lobe and isthmus on the involved side. The dissection has been carried to the extent that the spinal accessory nerves are completely dissected throughout their course

in the neck, as are the phrenic, the vagus, the recurrent laryngeal and the hypoglossal nerves. In addition to the above, the sternocleidomastoid muscle has been removed to facilitate ease of exposure and radicalness of the dissection in all cases, and it has been surprising how little disfigurement has resulted.

Because from the clinical, histological and surgical points of view the diagnosis and treatment of thyroid cancer have been involved with considerable differences of opinion, there has been no unanimity of opinion as to which patients should have radiation treatment following operation and, if treated, how much irradiation should be given. There has been disagreement over the length of time that radiation should be delivered and the quality of radiation that should be used. It would obviously take a large series of cases and several years to determine all these points. From our series of 428 cases with subsequent follow-up studies, the various types can now be evaluated and we hope some of the existing problems clarified.

Our 428 cases of thyroid cancer have been reviewed and classified as to the clinical extent of disease into four stages (Table 3). In Grade I tumors rated as

Table 3. Clinical Stage of Disease at Operation

STAGE	EXTENT
I	Malignant lesions still within capsule
II	Cancerous invasion of surrounding tissue
III	Cancer with lymph node involvement
IV	Cancer with distant metastases (lungs, bone, liver, brain and so forth)

in Stage I, comprising 136 cases, the malignant neoplasm was still within the capsule in 112, or 82 per cent of the cases (Table 4). We have considered it unnecessary to employ postoperative irradiation on those tumors of this grade that have remained encapsulated. When, however, they have shown extension into either surrounding tissue or lymph nodes (approximately 11 per cent of the cases), we have advised postoperative radiation treatment (Table 4).

In the Grade II tumors (Table 4) the histological grading is of the utmost importance, since the relative cure rate between the papillary adenocarcinoma and the alveolar adenocarcinoma varies so widely. The excellent nonrecurrence results obtained in patients with adenomas with papillary adenocarcinoma (Grade II) not irradiated have led some observers to believe that surgical enucleation is the sole treatment necessary. These tumors are, however, less likely to remain encapsulated than are the Grade I lesions. Papillary adenocarcinomas tend to invade surrounding tissue and spread to lymph nodes more frequently than the Grade I tumors. Of 130 cases, the lesion was entirely within the capsule in 68 or 52 per cent, as opposed to 82 per cent of Grade I tumors.

After surgical and radiation treatment in this grade (II), there have been 8 patients who have had recurrences that have required further surgery or radiation treatment. In 5 cases, the cancerous growth was so far advanced at the time the patient came to us for treatment that the only surgical procedure possible was biopsy. These patients received only roentgen treatment, and, while there was not complete clinical disappearance of the disease, the group of patients lived and were active for an average of 9.6 years. This indicates two facts: (1)

Table 4. Clinical Stage of Thyroid Cancer at Operation

HISTOLOGICAL TYPE	TOTAL CASES	STAGE I No.	STAGE I %	STAGE II No.	STAGE II %	STAGE III No.	STAGE III %	STAGE IV No.	STAGE IV %
Grade I									
Papillary cystadenoma	76	58	76.3	14	18.4	4	5.2	..	...
Alveolar adenoma	60	54	90.0	2	3.3	4	6.6	..	...
Total	136	112	82.3	16	11.7	8	5.8	..	...
Grade II									
Papillary adenocarcinoma	130	68	52.3	34	26.2	27	20.7	1	0.77
Alveolar adenocarcinoma	48	27	56.2	8	16.6	12	25.0	1	2 0
Total	178	95	53.3	42	23.6	39	22.0	2	1.1
Grade III									
Small cell, compact	40	9	22.5	6	15.0	25	62.5	..	...
Small cell, diffuse	29	4	13.8	5	17.2	20	68.9	..	...
Giant cell	29	5	17.2	3	10.3	21	72.4	..	...
Hürthle cell	7	3	42 8	1	14.3	3	42.8	..	...
Fibrosarcoma	9	2	22.2	2	22.2	5	55.5	..	...
Total	114	23	20.1	17	14 9	74	64.9	..	...
Total cases	428								

that this type of lesion is a slowly growing one and (2) that these lesions can be quite satisfactorily controlled with adequate irradiation.

We have classed alveolar adenocarcinomas as one of the most dangerous of all malignant thyroid tumors. They are frequently entirely within the capsule at the time of operation—in 27, or 56 per cent, in the series of 48 cases reported here. The five-year survival rate in this group has been only 29.1 per cent. This suggests that there has been an early spread of the disease beyond the surgical field and that in spite of postoperative irradiation of the tumor bed, the tumor had not been completely destroyed. Since the amount of radiation (4,800 r) given to these tumors has not been sufficient to stop their growth in all cases, we now believe it advisable, when possible, to increase the quantity of radiation. In order to do this we have improved the quality of the roentgen beam to prevent damage to normal structures.

The present method of giving radiation after operation is shown in the following outline:

1. Radiation therapy is started postoperatively as soon as the general condition of the patient warrants, usually six days.
2. Treatment is planned to cover tumor bed and surrounding lymphatics.
3. It is planned to deliver a total tumor dose of 4,800 r in 28 treatment days (170 r daily).
4. Half-value layer of 2 mm. of copper or better is employed.
5. Moist skin reaction is avoided.

RADIOACTIVE IODINE

Radioactive iodine is useful for two purposes in the treatment of thyroid cancer: (1) as a tracer to determine whether or not any tumor remains; (2) as a curative agent in cases of malignant thyroid tumors that take up iodine (I^{131}) in large enough quantities to destroy the tumor.

The use of radioactive iodine is limited because many of the malignant cells of thyroid cancer will not take up I^{131} and thereby avoid destruction. It is also limited by the fact that metastatic or persisting tumor tissue may assume a different microscopic grade from the original grading.

The iodine uptake of malignant thyroid tumors can be materially improved by total thyroidectomy. Thus, when secondary lesions are present that are being treated by this method, it is advisable to do a total thyroidectomy before treatment with radioactive iodine is begun.

I^{130} and I^{131} have for the most part been used in the treatment of Stage III and IV lesions. They are the most difficult of all thyroid cancers to treat satisfactorily. As palliative adjuncts these substances have proved of value largely against tumors that contain a moderate amount of colloid.

CONCLUSIONS

Some of the confusion as to the percentage of malignant changes in adenomas of the thyroid is the result of not reporting the percentage of malignant changes in the discrete adenomas of the thyroid and multiple adenomatous goiters separately.

The incidence of malignancy in this clinic in 1,971 discrete adenomas is 10.04

per cent. This incidence of malignancy in discrete adenomas of the thyroid is too high to justify delaying surgical intervention against such tumors.

All discrete adenomas of the thyroid, however small or however large and even in young people, should be removed as a prophylactic measure against the later occurrence of malignant degeneration in them.

The indications for radical dissection of the neck, followed by high voltage irradiation in cases of adenoma of the thyroid in which cancer is reported, are presented.

As the result of our study and experience with 428 patients with cancer of the thyroid gland, it has been made evident to us that the five-year survival rate without recurrence of the disease is very definitely correlated with whether or not the malignant neoplasm is entirely within the capsule at the time of the removal of the discrete adenoma. It has further been made evident to us that the number of patients with discrete adenomas of the thyroid in whom the cancerous growth is entirely within the capsule of the adenoma decreases very definitely as the grade of malignancy increases. These facts further justify the early and universal removal of all discrete adenomas of the thyroid.

Prophylactic removal of all discrete adenomas would do much to lower, if not abolish, the occurrence of cancer of the thyroid.

INDICATIONS FOR NECK DISSECTION IN CARCINOMA OF THE THYROID

RICHARD B. CATTELL

Progress has been made in the treatment of carcinoma of the thyroid by its earlier recognition, by a more radical surgical approach and by better radiation therapy. Furthermore, the use of radioactive iodine as a means of study and treatment of metastatic nodules as reported by Seidlin,[3] Trunnell,[2] Dobyns[3] and others has increased our knowledge of the function and behavior of thyroid malignancy. Earlier experiences with cancer of the thyroid demonstrated that the results left much to be desired when incomplete operations followed by radiation therapy were the methods of treatment employed. It is recognized today that the best results are obtained by radical operation followed by adequate roentgen therapy.

It is the purpose of this report to outline the indications for neck dissection in the presence of the different types and extents of carcinoma of the thyroid, as at present employed at the Lahey Clinic. It is felt that there has been no clear-cut accepted indication for the employment of neck dissection and it is hoped that our limited experience at the present time on this problem may be of some aid in arriving at a proper solution.

In the five-year period, 1945 to 1950, neck dissections on one or both sides have been carried out in 52 patient. All patients have received roentgen therapy postoperatively. It is, of course, impossible to report on the results of such therapy except during a short period of observation. The important finding in this group of cases was the fact that 88 per cent had involvement of the cervical nodes. It is well recognized that the life history of carcinoma of the thyroid shows that it may be slow-growing or it may remain dormant for years, but does eventually cause death in a considerable proportion of cases. This has been emphasized by Ward,[4] Frazell and Foote,[5] Crile,[6] Pemberton,[7] and Lahey, Hare and Warren.[8] In the light of our present knowledge, the operative procedure should be extended to include removal of the cervical nodes on the affected side to give the best chance for cure.

In our clinic we have been through three periods of surgical treatment for thyroid cancer. The first was chiefly concerned with establishing the diagnosis by biopsy and the relief of pressure by tracheotomy, followed by roentgen therapy. The second period consisted of total lobectomy or total thyroidectomy, followed by more adequate roentgen therapy, which yielded some improvement in end results. During this period, occasional neck dissections were carried out subsequent to the operation on the thyroid when the nodes were shown to be involved by clinical examination or by biopsy.

During the past five years we have combined lobectomy or total thyroidectomy

Originally published in Journal of Clinical Endocrinology, *10*.1099–1107 (Sept.) 1950.

with neck dissection much more frequently, and feel that this method of extending the operation offers the possibility of further improvement of the end results. In the light of the fact that nodes were involved in 88 per cent of these patients having neck dissections, it would seem that this is a common finding with carcinoma of the thyroid and that neck dissection should be more frequently adopted.

Carcinoma of the thyroid may spread by a number of routes. In our experience the commonest spread is a contiguous invasion of surrounding structures. The prethyroid muscles, particularly the sternothyroid muscle, are frequently involved. Similarly, direct spread may occur to the carotid sheath and its contents, but particularly, direct invasion may occur through the middle thyroid vein to the jugular vein. The trachea and esophagus may be directly involved and extension may occur into the upper mediastinum.

Spread through the lymphatics to the deep chain of cervical nodes with later involvement of the more superficial nodes is common. Lymphatic extension into the mediastinum likewise is noted. Cope[9] called attention to the early involvement of the Delphian node even when the clinical and operative diagnosis could not otherwise be established except by microscopic section.

Blood vessel invasion within the primary tumor of the thyroid is a frequent finding as originally called attention to by Allen Graham in 1926. So far as the eventual result goes, in the presence of this finding we cannot predict the prognosis. An analysis of our own cases by Warren[10] showed that when, on microscopic examination, this finding alone was the only indication of possible malignancy, approximately 6.3 per cent had a malignant course.

The decision to perform neck dissection can be reached by two means—clinical and histologic. The diagnosis of carcinoma of the thyroid may be obvious from the examination of the patient. If a lobe is hard and fixed and there is a history of rapid growth with or without demonstrable cervical nodes, a presumptive diagnosis of carcinoma can be made and a proper operation planned. Under such circumstances we believe that neck dissection and total lobotomy of the homologous lobe should be undertaken at the initial procedure, confirming the diagnosis at operation by biopsy. If there is involvement of all of the thyroid with nodes present on both sides and probable mediastinal involvement, neck dissection is probably not indicated, as total thyroidectomy followed by roentgen therapy will accomplish as much as possible in the way of palliation.

The patient with frank thyroid cancer does not present such a difficult problem in planning surgical therapy; it is rather the one in whom malignancy was unsuspected, but demonstrated on microscopic study subsequent to operation. Without question, the most important means of attacking the problem of thyroid cancer is the early removal of discrete nodules, in which the incidence of malignancy is high. Although the figures from different clinics vary widely, Cole[11] has found malignant degeneration in 24 per cent of discrete nodules, Crile in 24 per cent, Ward in 15 per cent and we have found it in 10 per cent at the Lahey Clinic.[12] In the light of these figures, is total lobectomy indicated for all discrete nodules because of the frequency of carcinoma in them? Certainly it is justified whenever the adenoma is adherent or shows capsular invasion. In many patients the question can be answered by immediate frozen section examination, which

will also give the information needed for making a decision relative to neck dissection at the initial operation. If malignancy is proved, neck dissection should be accepted as part of this procedure, particularly if a papillary tumor is found. If the diagnosis of malignancy is established only after later histologic examination, neck dissection can be carried out at that time during the same hospital admission.

The decision for or against neck dissection for carcinoma of the thyroid can be made on the basis of the type of malignancy as reported by the pathologist. Table 1 shows the type of malignancy present in the 52 patients submitted to

Table 1. Neck Dissection for Carcinoma of Thyroid: Type of Malignancy

Adenoma with blood vessel invasion		1
Papillary cystadenoma, malignant		8
Papillary adenocarcinoma		24
Alveolar carcinoma		8
Carcinoma simplex		11
Small cell	8	
Giant cell	3	
Total		52

neck dissections by us during the past five years. A review of our experience with this series of cases indicates that with extensive malignancy, such a procedure may not be justified by the results.

Adenoma with Blood Vessel Invasion

When a discrete nodule has been removed that shows blood vessel invasion within the localized tumor as the only finding suggesting malignancy, one cannot consider such a lesion as being definitely carcinoma. Furthermore, if spread has occurred, it probably has passed beyond the field of possible surgical extirpation. With this finding, neck dissection is not indicated unless nodes can be palpated. In only 1 patient in this series was neck dissection done and no involved nodes were found. It is important, however, to state that blood vessel invasion was present in 23 patients in whom other signs of malignancy were present.

Papillary Cystadenoma, Malignant

This small group of 8 patients had a relatively low grade of malignancy. The diagnosis was usually made by biopsy of a cervical node or by microscopic examination of a discrete adenoma. Capsular invasion was characteristically present. This group is part of the papillary tumors, all of which must be considered malignant. Crile has suggested that local excision of nodules lateral to the jugular vein or sternocleidomastoid muscle may be sufficient for control. In spite of their slow rate of growth, one cannot eradicate all possible involvement in the glands without at least unilateral neck dissection and lobectomy on the same side. These tumors may develop into papillary adenocarcinoma if left in situ. They fall into the debatable group formerly termed "lateral aberrant thyroid." Warren and Feldman,[13] in reviewing 56 of our patients, found the homologous lobe of the thyroid involved in over 90 per cent, indicating probable origin from the median

anlage of the thyroid, that is, a definite carcinoma of the thyroid with metastases to the lateral cervical nodes. Although such a theory will not explain all cases, we concur with their opinion that most of the lateral papillary tumors are metastases. Irrespective of their mode of origin, however, whether from the median or lateral anlage, the indication seems clear for a neck dissection in all cases.

Papillary Adenocarcinoma

This is the largest group of patients, 24 in number, that we have submitted to neck dissections, but we have included solid adenocarcinomas in this category. These tumors have the same frequency of involvement of the cervical nodes as the malignant papillary cystadenomas, and require neck dissection. Frequently, foci of alveolar carcinoma or carcinoma simplex may be present, particularly in the lymph node metastases. Invasion of contiguous structures both at the primary site and around the metastases are common, making a block excision mandatory in order to have any possibility of eradication of the malignancy.

Alveolar Carcinoma

Eight patients with alveolar carcinoma had neck dissection performed. Nodular involvement is the rule in this type of malignancy, yet we have encountered it in a discrete adenoma without palpable nodes. A report, however, of alveolar carcinoma is sufficient indication for proceeding with neck dissection on that side.

Carcinoma Simplex

In this group are the most extensive and rapidly growing of the thyroid carcinomas. We agree with Pemberton[7] and with Black[14] that radical operations are rarely indicated when the extensive involvement of a diffuse small cell carcinoma or giant cell carcinoma is present. We have, however, performed neck dissections in 11 patients with this type of tumor, but have obtained the poorest results, as would be anticipated, in any of the types of thyroid malignancy. As the author recommended in 1946,[15] in this type of thyroid cancer we attempt as complete removal of the primary tumor as possible, perform tracheotomy, and follow the operative treatment by adequate roentgen therapy. Partial neck dissection may be feasible in order to remove large portions of malignant extensions of the glands for the purpose of permitting more effective radiation therapy. We have 1 patient living eight years after the removal of an extensive giant cell carcinoma with this combined treatment.

Extent of Involvement

In the group of 52 patients who had neck dissections, 6 were found to have no involvement of the cervical nodes or soft tissues removed in the dissection, but 46 or 88.5 per cent had involvement of the nodes (Table 2). As will be noted in this table, extensive involvement was present in a high percentage of all patients submitted to this operation. In 18 patients, involvement was limited to the nodes; but in 17, the finding of blood vessel invasion in the area of metastases was noted. In addition to this, 11 patients had soft tissue involvement as well as node and blood vessel involvement Neck dissection in this series thus was the means of removal of many metastases and was justified in this selected group

After a sufficient postoperative time interval the results may further justify our present opinion that neck dissection should be done in an increasing number of patients with thyroid malignancy.

Table 2. Neck Dissection for Carcinoma of Thyroid: Extent of Involvement

Thyroid only (nodes not involved)	6	11.5%
Cervical nodes	18	88.5%
Blood vessel invasion and nodes	17	
Blood vessel invasion, nodes, soft tissues	6	
Nodes and soft tissues	5	
Total	52	100 0%

THE OPERATION OF NECK DISSECTION

This operation can be carried out as part of the removal of the primary thyroid malignancy or at any time subsequent to it, depending upon the indications. The amount of the thyroid gland that should be removed either by total lobectomy or total thyroidectomy will depend upon the extent of the primary lesion. The prethyroid muscles, including the sternohyoid, sternothyroid and omohyoid muscles, together with the sternocleidomastoid muscle, the internal jugular vein, and the deep cervical chain of nodes, should be removed by block dissection. The field of operation frequently includes the entire occipital triangle and submaxillary triangle. If a unilateral thyroid removal is done, the parathyroids are sacrificed on that side. It may be justifiable to remove the vagus nerve or the recurrent nerve if it is included in involvement that can be satisfactorily removed. If, as in the case of some papillary tumors, there is involvement of the opposite side, bilateral neck dissection is done with a few days interval between operations but the jugular vein is saved on the least involved side. Tracheotomy is frequently found advisable at the completion of the dissection. Operation is performed under general endotracheal gas-ether-oxygen anesthesia.

There has been no operative mortality in the 52 patients submitted to neck dissection with partial or total thyroidectomy. All patients have received postoperative roentgen therapy and some recent patients have been treated by Dr. Hugh F. Hare in conjunction with Dr. John Trump with the two million volt machine at the Massachusetts Institute of Technology. If respiratory obstruction is avoided by frequent tracheotomies which are maintained until the completion of radiation therapy, there are few complications other than that of recurrence. In high dissections, the depressor anguli oris branch of the facial nerve may be divided. The thoracic duct was injured in 1 patient, resulting in a temporary fistula which closed following continuous suction, and the thoracic duct was ligated in the neck in a second patient, without complications.

Three patients of this group are already dead of recurrence. The first patient, a woman of 35, had a 2.5 cm nodule in the right lobe of the thyroid for one year. Excision was performed on August 11, 1948, for an encapsulated adenoma without clinical evidence of malignancy. Microscopic examination showed carcinoma simplex of the small-cell compact type with extensive blood vessel invasion. On August 20, 1948, neck dissection was carried out and the nodes and

soft tissues showed no malignancy. The patient died February 1, 1950, sixteen months after operation, with metastases to the orbit, brain, chest and pelvic bones.

The second patient, a girl of 16, had an increasing thyroid enlargement for six months, which was removed elsewhere July 3, 1947, and shown to be a small-cell carcinoma. Neck dissection and lobectomy were carried out July 10, 1947, and showed carcinoma simplex with blood vessel invasion and metastases to two of thirteen lymph nodes examined, and some tissue invasion as well. She died March 30, 1948, nine months later, with pulmonary metastases.

The third patient, a woman of 55, had a swelling in the thyroid for seven years which had showed sudden growth for three months. She was found to have involvement of both lobes with metastases to the nodes in the left neck. Total thyroidectomy and left neck dissection were performed, and the neoplasm was found to be a small-cell carcinoma with involvement of the nodes. She died twelve months later with metastases to the ileum, pleura and mediastinal nodes

Two additional patients already show diffuse pulmonary metastases three and four months after operation. One had a papillary adenocarcinoma and the other a giant-cell carcinoma, but both specimens showed blood vessel invasion. Although the finding of blood vessel invasion in frank carcinoma of the thyroid is a serious prognostic sign, as indicated by the 3 patients who are already dead and the fourth with pulmonary metastases, there are 23 other patients with this finding who are free of recurrence during a period up to five years after operation.

The utilization of neck dissection is well illustrated by the following case. In a girl of 5 years, a 1 cm. nodule appeared in the upper left neck in August 1949. There was gradual enlargement. Early in January 1950, nodes were found on both sides of her neck and on January 6, 1950, the original nodule was removed. Microscopic examination showed metastatic papillary adenocarcinoma with foci of carcinoma simplex.

On January 18, 1950, radical neck dissection and total lobectomy were performed on the right side. Because of local invasion, the recurrent nerve and phrenic nerve were sacrificed. The microscopic report was papillary adenocarcinoma with foci of carcinoma simplex, invasion of soft tissues and involvement of 11 of 29 lymph nodes examined. On January 26, 1950, the total thyroidectomy was completed with a modified left neck dissection, differing from the one on the right side only in that the internal jugular vein was preserved. Microscopic examination showed papillary adenocarcinoma with 6 of 23 lymph nodes involved. Tracheotomy was performed at the conclusion of the second dissection. Roentgen therapy with the two million volt machine has been completed.

It is in this type of papillary tumor, particularly in children and young adults, that either unilateral or bilateral neck dissection and total thyroidectomy should be employed.

SUMMARY

Experiences in the treatment of thyroid carcinoma demonstrate that involvement of the cervical nodes on the same side is common. Invasion of the prethyroid muscles, veins and soft tissues is frequently observed. Surgical extirpa

tion of the tissues in these zones of spread may be accomplished in some cases by neck dissection on one or both sides.

A series of 52 patients submitted to neck dissection is reported. The operation includes lobectomy or total thyroidectomy with removal of the prethyroid muscles, sternocleidomastoid muscle, internal jugular vein and deep and superficial lymph nodes.

Indications for neck dissection have been presented, based on the clinical and operative findings, as well as on the type of carcinoma present.

Particularly for malignant papillary tumors, neck dissection offers a better chance for cure and should be done in an increasing number of patients with this type of malignancy.

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RADICAL DISSECTION OF THE NECK

FRANK H. LAHEY

Because we have always had to deal with so many tumors of the neck and so many carcinomas of the thyroid, we are constantly faced with the necessity of radical neck dissection.

In a recent paper by W. A. Meissner and myself, published in *Endocrinology* and read before the American Association for the Study of Goiter, we presented our indications for radical neck dissection in malignancies of the thyroid. When frank cancer of the thyroid has occurred, has invaded and eroded the capsule of the adenoma it so frequently arises in, and has involved the parenchyma of the thyroid gland, we believe that radical and extensive neck dissection should be done, consisting of removal of all of the internal jugular from the mastoid to the clavicle and the removal of the sternomastoid from its insertion above to its attachment to the sternum and clavicle below.

Since many of these patients will have carcinomas of the thyroid which not only involve the parenchyma of the thyroid but also will have invaded the lymph nodes, many of these dissections will necessitate not only demonstration of the anatomical structures such as nerves, vessels and muscles, but will involve the removal of extensive glandular metastases from as low beneath the clavicle as possible, as far back toward the posterior triangle as possible and high up under the angle of the jaw since metastatic carcinoma, particularly of the papilliferous variety which we used to call aberrant thyroids, will involve regions thus extensively. It is for this reason that our experience with radical dissections of the neck, unlike many of the experiences of surgeons dealing with dissections of the neck for the removal of secondary gland involvement in carcinoma of the lip, tongue and mouth, will involve the frequent removal of large masses of involved tissue.

While we must also do secondary dissections of the neck for lip, tongue and buccal carcinomas, the majority of our radical dissections of the neck have been for carcinoma of the thyroid. For this reason, because of the peculiar capacity of carcinoma of the thyroid to invade particularly venous channels, we must not only include in our radical removal wide excisions of the original tumor and all of the nodes, but we must attempt to remove all of the internal jugular from the mastoid to the clavicle, together with all of its tributaries into which malignant growth could have extended.

One of the most important features of radical dissections of the neck is anesthesia, and intimately related to anesthesia is position. In Figure 41 is shown the amount of projection of the neck we have been able to obtain in thyroid operations and in operations for esophageal diverticula, by elevation of the shoulder bar placed well beneath the scapulae Nothing has been more important in

Originally published in Surgical Clinics of North America, 29.631–640 (June) 1949.

facilitating these radical neck dissections than the method of projecting the anatomical structures of the neck well up into the wound.

The relation of anesthesia to position is concerned with being able to have complete control of the patient at all times. With an endotracheal tube in place, as is employed by our anesthetists in all of these patients, one has at all times complete control of the patient so that there is no obstruction to breathing and no accumulation of mucus because, if mucus occurs within the tube, the latter can be disconnected from the anesthesia apparatus and the mucus removed by



Fig. 41. Note how the chest is thrown forward by the bar shown under the shoulders to accomplish forward projection of the area to be operated on. However, unless the bar is placed well down under the shoulders, this will decrease the distance between the chin and the sternal notch rather than increase it. Note the exaggerated rotation of the chin to the opposite side from the region to be operated on to increase the prominence of the sternomastoid and to project into the wound the structures to be removed.

suction. If no endotracheal tube is employed and there is any interference with breathing as a result of coughing and movement, the patient may so move himself out of position as to interfere seriously with the exposure and anatomical demonstration of important structures.

The next most important factor in my experience in dealing with these radical neck dissections is the type of incision employed, because unless adequate flaps are established as a primary step in the operation it will not be possible to obtain what is so important in this type of operation, namely, wide exposures above, below and in both directions laterally. One needs to be able to carry the posterior incision well back beyond the course of the spinal accessory and in front, the skin incision must often be elevated and carried well over onto the other side in order to expose the opposite lobe of the thyroid to determine the presence or absence of nodules within it. In the inset in Figure 42 is shown the type of incision commonly employed by so many surgeons in radical neck dissections and the one which has served us well in this type of radical neck dissection which we have to do so often. With the oblique incision running from the sternomastoid along its entire anterior border down to the clavicle and then turned sharply

backward, it is possible to obtain completely satisfactory exposures and at the same time restore the skin flaps without undue disfigurement.

With the skin flaps widely exposed, as shown in Figure 42, I have personally preferred to start the dissection by demonstration of the spinal accessory nerve posteriorly.

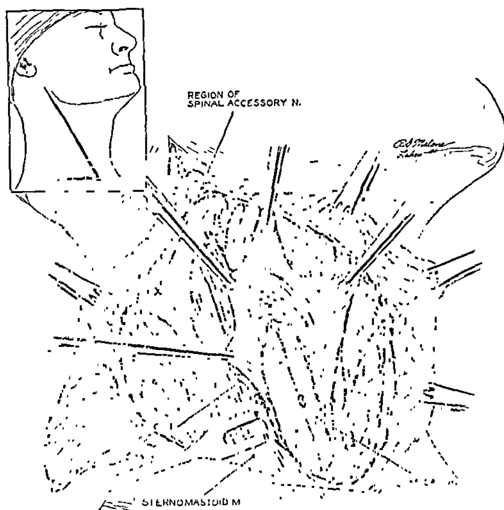


Fig 42. *Inset,* The type of incision which we have employed in these radical neck dissections. This heals well, as shown in Figures 46 and 47, which are photographs of two patients on whom the operation had been done several months previously.

In the above figure is shown the wide exposure made possible by dissection beneath the skin flap and wide lateral retraction. Note at "X" the region of the spinal accessory nerve which can be found, long before the nerve is seen, by stimulating this region with the nerve stimulator, thus bringing about contraction of the trapezius and betraying the exact location of the nerve so that it can be detected more easily. Note the complete separation of the internal jugular and common carotid in front of the sternomastoid to make easy the ligation of the internal jugular at its lowest point.

The most important single thing that has aided us in neck dissections has been the nerve stimulator, as shown in Figure 43. By means of this apparatus, which was supplied to us several years ago by the neurosurgeons in the clinic, who stimulated our interest in its employment, it is possible to determine the course and presence of nerves well before they are actually seen. When dissections must be done in the presence of malignancy, this is of the greatest value. When one reaches the region of the oblique course of the spinal accessory nerve, it is of

greatest comfort to be able, with a mild stimulating current, to bring about the trapezius contraction that identifies the course and the direction of the nerve well

Fig. 43. The stimulating apparatus employed by many neurosurgeons, by means of which the nerves can be identified by muscles they contract and their course and location determined before they are actually exposed.

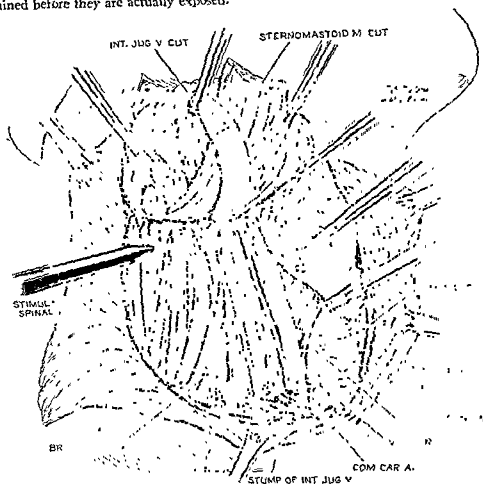


Fig. 44. The sternomastoid has been severed, the internal jugular ligated and block dissection of the vessels, nodes and fat has been carried upward for the exposure of the underlying structures. The stimulator is placed upon the spinal accessory nerve. Note the exposed brachial plexus, the phrenic nerve, the vagus and the recurrent laryngeal nerve. Note how the thyroid gland involved in malignancy is dissected free from the trachea, carried upward and the recurrent laryngeal nerve is dissected free to the point where it enters the larynx.

before it is seen so that precautions can be employed as it is dissected out of its course. With the spinal accessory nerve completely demonstrated from where it emerges under the posterior belly of the sternomastoid, as shown in Fig. 44, down

to the point where it disappears under the edge of the trapezius to become the subtrapezius plexus, the dissection can then be carried forward just above the clavicle until the edge of the scalenus anticus can be demonstrated, and distal to it the brachial plexus, and internal to it the phrenic nerve running on its anterior surface. The phrenic nerve likewise can be demonstrated before it appears, if there is any doubt, by stimulating the tissue on the anterior surface of the scalenus anticus with the galvanic current stimulator and watching for contractions of the diaphragm which can readily be seen through the sheet covering the abdomen. One should be careful in employing this stimulating current on the phrenic nerve to cut it down to a minimum intensity since stimulation of the phrenic nerve with a high current can produce quite violent diaphragmatic contractions.

With the phrenic nerve demonstrated, the brachial plexus can readily be demonstrated likewise with the stimulating current, but there is little likelihood of injuring the brachial plexus in most of the radical dissections of the neck since it is at a deeper level than the phrenic or the spinal accessory nerve. With the phrenic nerve well demonstrated on the anterior surface of the scalenus anticus, the internal jugular can be seen from behind. The prethyroid, sternohyoid and sternothyroid muscles can then be separated in the middle line until the isthmus of the thyroid is well visualized. The fibers of the sternomastoid are then best severed close to their attachment to the sternum and to the clavicle by repeated short strokes of a knife rather than by attempting to clamp and tie the vessels. By this method each small bleeding vessel in the muscle can be picked up and tied with silk and the severing of the muscles continued until the trunk of the internal jugular vein itself appears. The internal jugular vein, having been identified and separated from the common carotid, with care to preserve the vagus, is then ligated with a double silk ligature and ligated again with a single silk ligature and the dissection is then started from below upward and from without inward. This establishes a definite line of cleavage by means of which all of the anatomical structures of the neck and the thyroid can be identified step by step and made plainly visible.

With the entire mass of the sternomastoid, internal jugular and the beginning of the lateral neck dissection pulled inward and upward, the phrenic nerve dissection can be carried up along the scalenus anticus, the fat and involved glands overlying the brachial plexus can be separated upward, the course of the spinal accessory can be followed up to the point where the branch is given off to innervate the sternomastoid and this can be severed to mobilize the spinal accessory from the sternomastoid as it is turned inward toward the middle line. As the internal jugular is pulled inward and the dissection is continued from below upward, the common carotid becomes more and more visible, and as the common carotid is pulled outward by blunt dissection, the inferior thyroid artery as it passes beneath the common carotid is seen and can be ligated either external or internal to the common carotid in its position behind it.

With the inferior thyroid artery exposed, even though the thyroid gland may be involved in carcinoma, the recurrent laryngeal nerve can be identified in almost every case and dissected throughout its course. In order to do a total thy-

roidectomy, as is so often necessary when carcinoma of the thyroid has involved the thyroid gland itself and has invaded the adjacent lymph nodes, it will be necessary to ligate and sever the inferior thyroid artery so that the nerve, if it runs beneath the artery, can be exposed throughout its entire course up to the point where it enters the larynx, and thus completely preserved even though all of the thyroid gland on that side be removed.

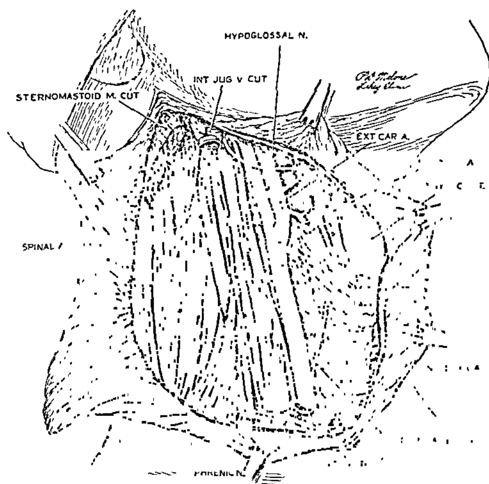


Fig 45. The operation completed, the internal jugular ligated below and above, with the sternomastoid muscles severed below and above and removed.

Note again in this dissection, with the operation completed, that the spinal accessory nerve is completely in view, the phrenic nerve on the outer edge of the scalenus anticus is exposed, the vagus nerve is freed from its sheath, the recurrent laryngeal nerve is visible up to its point of entrance into the larynx and the hypoglossal nerve throughout its tract. Note the inferior and superior thyroid arteries ligated and severed. The small thyroid gland has been completely removed up to the isthmus on the other side so that the trachea is completely bared.

As the thyroid is separated in the middle line from the isthmus, the isthmus on the other side is clamped and the bleeders in it are tied, the entire thyroid gland is removed, the superior thyroid artery is tied and all of the thyroid gland, sternomastoid, internal jugular and areolar tissue and nodes of the remainder of the cervical triangle are carried upward with the dissection. As the dissection finally reaches the division of the common carotid, again the stimulator will be of value in demonstrating the presence of the hypoglossal nerve, often even

before it can be seen, although in most of the cases it will readily appear as it crosses the division of the common carotid into the internal and external carotids at this level.

With the hypoglossal nerve exposed, the entire thyroid removed, all of the inferior thyroid artery tied, and the spinal accessory, brachial plexus, phrenic nerve, recurrent laryngeal nerve and hypoglossal nerve in view, the dissection of the upper triangles of the neck is no longer difficult. The line of cleavage is continued upward, any involvement in the submaxillary triangle is thoroughly cleaned out, the facial vein and artery are controlled, and the dissection is carried backward until the mass of tissue in one block, as shown in Figure 45, represents attachment above only by the sternomastoid and the internal jugular vein. The dissection behnd the sternomastoid well up to the point where the spinal accessory nerve disappears is completed and the dissection in front from the attachment to the ramus of the jaw is likewise completed. Again, as when the internal jugular was previously ligated, the sternomastoid muscle is gradually severed by short gentle strokes, taking pains to grasp each bleeder as it appears in the muscle until the internal jugular vein is completely identified and isolated. This structure, as was done at its lower end, is ligated with double silk and again with single silk, the entire mass is freed and the operation is then completed. All bleeding points are carefully sought for and controlled, and a rubber dam drain is placed in the central portion of the wound and made to emerge from the posterior angle of the lower portion of the incision as it runs along the clavicle. The remainder of the wound is closed with clips, and a firm bandage is applied to bring about sufficient pressure to control ooze, but not enough to interfere with breathing since one must remember that the trachea in this operation has been completely bared and undue pressure upon it from bandages can result in tracheal obstruction.

It is well to employ a silk stitch at the angle of the wound to make certain of anchoring the skin at this level, but clips may be applied in all of the remaining portion of the wound and, as in thyroid operations, removed half on the second day and half on the third day. The rubber dam is to remain in the neck for nearly a week since this is a large space and one does not wish to remove the drain until the skin flap has become well adherent to the underlying structures.

There is one point about which patients should be warned in connection with these radical dissections of the neck. It is impossible, we believe, to do these radical dissections of the neck, with complete removal of all possibly involved nodes in the regions beneath the angle of the jaw, without injuring the submaxillary branch of the facial nerve. This is the branch which, as everyone knows, supplies the depressor anguli oris on that side, and its injury results in the inability of the patient to pull down the corner of the mouth on that side when he smiles.

It has proved wise in our experience to warn patients and their friends beforehand of the occurrence of this moderate disfigurement so that they will not interpret the explanation for it after operation as an apology. We have stated simply that this is one of the prices they must pay to obtain the benefits of the radicalness of this operative procedure.

Patients who have had to have this operation have been, in many instances,

greatly worried about the disfigurement. For that reason we have chosen at random, for illustrative purposes (Figs. 46 and 47), two patients who happened to come into the clinic at the time this article was being written, two girls in whom these radical dissections had been done with complete removal of the sternomastoid, the internal jugular, the thyroid gland on that side and exposure of all the nerve structures and fascial planes described in this operation.



Fig. 46.



Fig 47.

Fig. 46. This photograph shows the neck of a patient upon whom a radical complete dissection for carcinoma of the thyroid involving the nodes was done, with removal of the internal jugular throughout its entire extent, the entire sternomastoid, all of the nodes and the entire thyroid up to the isthmus on the left and the left lobe of the thyroid.

Note the absence of shoulder drop and only moderate sinking in of the neck on the right side as compared with the left.

Fig 47. This photograph is that of a young girl who also had complete dissection of the left side of the neck, the removal of the entire internal jugular, sternomastoid muscle and thyroid gland together with the isthmus on the left side. Note that in spite of this radical dissection there is very little disfigurement, as seen in a comparison of both sides.

One would expect that, as the result of the removal of the sternomastoid, the internal jugular and the thyroid, there would be an unsightly projection of the trachea and an unsightly sagging of the neck on that side. Such has not been the case, as can be seen in these illustrations. With preservation of all the nerve structures there has been no disability of any importance and the disfigurement has really been of a trivial character.

TRACHEOTOMY AFTER THYROIDECTOMY

FRANK H. LAHEY AND WALTER B. HOOVER

INDICATIONS FOR TRACHEOTOMY

As long as thyroidectomies are done there will be occasional postoperative cases in which tracheotomies must be done. The patient's life will often hinge upon whether or not they are done early enough. In practically every case in which the patient dies after a tracheotomy which has been done to relieve obstruction to breathing after thyroidectomy, one can say that the patient would have lived and been a normal individual had the tracheotomy been done earlier.

It is evident from this statement, based upon a large experience with thyroidectomy and postoperative tracheotomy, that one of the last few remaining, unconquered, controllable mortality factors in thyroidectomy is the time factor for post-thyroidectomy tracheotomy. We are prompted to make this statement by a desire to help others avoid this controllable mortality by directing attention to it, by stating that we have lost cases by not doing tracheotomies soon enough, by trying as the result of past experiences to set down warnings about when tracheotomies should be done, and to reassure surgeons not only of their life-saving value but also that they delay the hospital stay but little and add little to the discomfort or disfigurement of the patient. We wish also to describe how these tracheotomies may be done so that they will function most effectively and close spontaneously in the shortest possible time after removal of the tube.

Thyroidectomy cases will vary in the degree of intralaryngeal edema which will occur after operation, and upon this factor will depend, in a majority of the cases, the number of postoperative tracheotomies which will need to be done. Some of the cases will be only mild in which tracheotomy will not even need to be considered. Some will be extensive and urgent, resulting from the edema and in some cases from hemorrhage beneath the muscle flaps, so that it will be evident that prompt, even instant tracheotomy is imperative to save the patient's life. Between these two extremes will exist patients with varying degrees of tracheal obstruction, from those who are having difficulty in getting in enough air but improving, to those who are not getting in enough air and definitely getting worse.

Over the years we, as have many others, have struggled by every means at our disposal to continue the reduction of the mortality and morbidity rate of subtotal thyroidectomy. We reported in the paper[1] read before the Boston Surgical Society an over-all mortality rate for thyroidectomy in all types of thyroid disease of 0.75 per cent operative rate and 0.88 per cent patient rate. At that time our mortality for patients with hyperthyroidism, however, was approximately 1 per cent. In 1837 patients operated upon in the last three years, all of

Originally published in Annals of Surgery, 133:65–76 (Jan.) 1951. J. B. Lippincott Co., publishers.

whom had hyperthyroidism and were prepared for surgery with the antithyroid agents, there have been but 4 deaths, making a mortality rate of 0.21 per cent. Of these 4 deaths, 2 were due to coronary disease and not readily avoidable, and 2 were due to tracheal obstruction in which tracheotomy was done too late and in which earlier (by hours only) tracheotomy would have saved both of these patients' lives. We would, perhaps, not feel the need to write this article on the basis of just these two avoidable losses of lives, but not only has this happened to us in the years prior to this experience but also there have been occasional other patients over the years who have recovered with too narrow an escape from a fatality to leave us as contented as we would like to be.

There are four outstanding conditions with and after thyroidectomy which will require tracheotomy: (1) the postoperative edema of the larynx spoken of earlier in this discussion; (2) the postoperative accumulation of blood beneath the muscle flaps, usually the result of arterial hemorrhage either from the inferior thyroid artery or the superior thyroid artery, the postoperative venous oozing either beneath the muscle flap or beneath the skin flaps; (3) the narrowed trachea from intrathoracic or partly intrathoracic goiter in which there is a question that the patient will be able to get enough air through immediately after operation, and (4) the deliberate tracheotomy at the time of operation done upon patients with cancer of the thyroid as a precaution against the compression of the trachea which will follow the reaction and swelling after high voltage x-radiation which is employed postoperatively in these cases.

In discussing the indications for tracheotomy in the first and second groups of patients, those with increasing edema of the larynx and those with increasing accumulation of blood, arterial or venous, beneath the skin flaps or beneath the prethyroid muscles, it is impossible to state specifically just when tracheotomy should be done. We can only discuss this situation in quite general terms based upon this considerable experience with thyroidectomy and the postoperative problems related to interference with breathing. Since most of these cases in the first group, laryngeal edema, will certainly at first be non-urgent in character, it is obvious, unless the surgeon is to give up everything else to stand by this patient until the decision is made that the breathing is improving or getting worse and will require a tracheotomy, that the interpretation of the patient's adequacy of air intake will be largely in the hands of a nurse. This will be particularly true during the night and it is during the night after operation and the next night that these patients are lost from this complication. It is during the night that fewer nurses are on duty and fewer nurses with experience in the handling of postthyroidectomy patients are available for opinions as to whether or not a doctor should be called. It is during the night that, if a doctor is called, he is one who is frequently the least experienced of the surgical staff. It is during the night that postthyroidectomy patients are most likely to receive sedation which slows respiration and definitely adds to their inability to get in enough air. It is during the night when patients are observed in darkened rooms with an inability to settle clearly the satisfactoriness of the rate of oxygen exchange and it is during the night that the fatal decision, as the result of the above factors, is made that the patient can go until morning when the decision for or against tracheotomy can be more positively made. It is often true that by morning the decision

can be made more positively, but, particularly in the gradually increasing respiratory obstruction which occurs with postthyroidectomy laryngeal edema, the more positive the decision for tracheotomy in the morning the greater will be the number of patients in whom it will be done too late, and the greater will be the number of patients in whom it will be evident that the decision for tracheotomy should have been made during the night and not deferred until the morning. If there is an error of judgment which causes the surgeon greater depression and self-criticism than that of deciding to do a tracheotomy when it is too late and when a review of the case demonstrates that a tracheotomy done hours earlier would have saved the patient's life, we do not know it.

The danger of waiting too long before doing a tracheotomy in postthyroidectomy patients with breathing difficulties is such that if any patient in this group has any real urgency of breathing difficulty, the surgeon who did the operation or a really experienced assistant should be called and the responsibility for the decision for or against tracheotomy placed directly upon him. In addition, any surgeon called to make the decision for or against tracheotomy in a postthyroidectomy patient should make the decision only from two possible safe approaches. If he has the slightest doubt about the patient's oxygen exchange being adequate he should at once do a tracheotomy and if he is still in doubt but not sufficiently convinced that immediate tracheotomy should be done, then he or someone with experience should not leave the patient day or night until he is convinced that the oxygen exchange is improving and a tracheotomy will not be required.

We know of no decision which may be more difficult to make or one which often lacks positive evidence upon which to make it than this one. There is a period of suboxygenation in these partly obstructed patients during which, unless one has had considerable experience with it, one can be deceived into thinking that the air intake is sufficient, then, as the result of the prolonged but not striking anoxia, the decision is made so late that even with the establishment of a satisfactory intake of air by tracheotomy, the patient does not recover.

Unlike the rapid and urgent tracheal obstruction that occurs in postthyroidectomy patients when hemorrhage occurs beneath muscles, the gradual interference with air intake which occurs with the first group, laryngeal edema, is deceptively slow and possessed of no compelling features as is the case in the active hemorrhage group. It is this first group of cases, the laryngeal edema group, that has caused one of us (F. H. L.) to preach for years that the time to do a tracheotomy or reopen the wound to relieve pressure in postthyroidectomy patients with breathing difficulty is when one begins to wonder whether or not he should not do it. We have always recognized that this statement could very well promote the doing of more tracheotomies or wound re-openings than are necessary. We believe, however, that since laryngeal edema and partial respiratory obstruction in postthyroidectomy patients are so difficult to interpret and so capable of resulting in a fatality by tracheotomy delay, we would prefer this position since it leaves us with a live patient.

In the second group of postthyroidectomy patients in whom the decision for or against tracheotomy must be made, particularly those in whom the respiratory obstruction is brought about by the occurrence of arterial hemorrhage (superior

or inferior thyroid artery) beneath the prethyroid muscle layer, sternohyoid and sternothyroid, the decision is much more easily made because of the rapidity with which the obstruction occurs and because of the completeness of its character. It is a decision about which there can be less delay and often one which must be made in terms of minutes. An arterial hemorrhage from the superior or inferior thyroid artery consists of an outpouring of blood into a tightly closed space through which passes the collapsible air intake tube, the trachea. To appreciate fully the degree of compression which can occur in these cases it may be realized that the pressure is in some measure comparable to that produced by a blood pressure.cuff on the arm to obliterate the radial pulse.

The obstruction in the cases in this group is so complete that the decision will not be so much whether or not it should be done but whether or not it can be done in time. Such is the suddenness and rapidity in this type of obstruction to respiration that it will at times not be possible to get a doctor to the patient in time to do the only thing which will save him, that is prompt opening of the wound, separation of the sutured muscles and removal of the blood clots, and the holding of a gauze pack over the bleeding vessel until surgical help can be obtained and the arterial bleeding controlled.

Tracheal obstruction from arterial bleeding of the superior or inferior thyroid artery is quite different from the situation in which the obstruction is gradual and progressive as the result of accumulating and increasing edema of the larynx. In arterial hemorrhage the obstruction to respiration builds up much more quickly, is much more complete, and must be dealt with promptly if a life is to be saved. It is in this type that the impending diminishing adequate state of oxygen exchange is so obvious to the experienced nurse, assistant or surgeon that preparation for deliberate tracheotomy or re-opening of the wound must promptly be made. If one will palpate the neck in these cases, a distinct sense of firmness of the front of the neck, with a forward projection of the muscles and skin flaps, can be felt, owing to the accumulation of blood beneath the muscle flaps, a distinct forward tension of the sutured prethyroid muscle flaps can also be felt. When rapidly increasing bleeding difficulties occur and this type of firmness in the thyroid wound is felt, immediate surgical aid should be sought, and preparations should immediately be made at the patient's bedside by the nurse in the way of sterile goods and instruments to open the wound should the obstruction to breathing increase to a degree where it produces any evidences of cyanosis and difficulty in obtaining an adequate air intake. We would particularly like to urge, on the basis of our own experience, that if in such a case of rapidly increasing difficulty in breathing and diminishing adequacy of air intake, a surgeon or surgical assistant cannot be immediately obtained, the nurses should be instructed in any hospital where many thyroidectomies are done to take out the stitches without an anesthetic, to elevate the skin flap and, if embarrassment to respiration progresses, cut out or rip the stitches in the sutured prethyroid muscles, spread the muscles, bail out the clot with the fingers and control the arterial oozing by placing a pack over it and by finger pressure, taking pains to avoid compression of the trachea, until a surgeon is available to find and ligate the arterial bleeding vessel.

At least ten times in our experiences over the years with thyroidectomy, all of

us have had the experience of saving lives of patients in such extremis by ripping the wound open with unsterile hands, with unsterile instruments, sometimes with sewing scissors, by bailing out the clots and controlling the bleeding vessel, and then deliberately controlling the arterial bleeding vessel by ligature. It is important to remember that such can be the emergency of tracheal obstruction from arterial hemorrhage beneath the muscle and skin flaps that relief of pressure by opening the wound and removing clots supersedes asepsis and that in none of the cases in which this has been done has there been any troublesome infection. In most of these patients simple removal of the clots will restore an adequate oxygen intake. When, however, it does not do so promptly, a tracheotomy should be done.

There are one or two technical points in thyroidectomy which should be mentioned at this point that will diminish the chances of postthyroidectomy arterial hemorrhage. While this paper does not deal with the technical side of thyroidectomy, it is, we believe, worthwhile to introduce these steps at this point in an attempt to avoid this dangerous and urgent type of tracheal compression.

The first point is that for a number of years now we have made it an important step in the operation after subtotal thyroidectomy is completed to expose the stump of the superior thyroid artery where it has been previously ligated and cut, to grasp it with a right angle clamp and to retie it a second time at a higher level than that at which the previous ligature was placed. It is important to remember that not infrequently the elevation of skin flaps in large thyroids is inadequate for good exposure of the superior thyroid artery and that it is not infrequently ligated without good visualization and that, having been ligated so close to the point where the artery enters the uppe pole, the artery is occasionally cut off with an inadequate excess of artery distal to the ligature to insure against slip-off of the ties.

It is to be remembered also that the thrust in the superior thyroid artery is tremendous. Since it is the first branch of the external carotid, there are two features about this ligated vessel which promote the possibility of hemorrhage: the one already spoken of—that it is frequently cut too close to the ligature owing to bad exposure—and the other that being the first branch above the carotid sinus where the common carotid divides into the external and internal, *there is* here a tremendous degree of arterial pressure.

The other warning that we would like to urge is that ligature of the inferior thyroid artery should be done in continuity and that the artery should not be cut beyond the ligature. One ligates the inferior thyroid artery in subtotal thyroidectomy merely to contol bleeding from the lower part of the thyroid while the subtotal thyroidectomy is being done, and one is not concerned with whether or not revascularization of the gland occurs through the channel of the inferior thyroid artery.

One of us (F. H. L.) has frequently stated to visiting observers that if the inferior thyroid artery is ligated and cut, it adds materially to the danger of the tie blowing off and the occurrence of secondary hemorrhage and the type of obstruction spoken of above. If the inferior thyroid artery for any given reason does require severing, one should, as in the superior thyoid artery, apply a second protective tie well beyond the original ligature. Observation of these two steps

in the control of the arterial blood supply to the thyroid has, in our own experience, markedly diminished the number of patients in whom postoperative arterial hemorrhage occurs and, consequently, the occurrence of the emergency type of tracheal obstruction spoken of above.

The third type of tracheal obstruction listed is that in the patient with an intrathoracic or partly intrathoracic thyroid, as shown in a recently operated patient, in whom there was a marked degree of tracheal narrowing (Fig. 48). It has been our experience that in most of the patients with this degree of tracheal narrowing, tracheotomies will not be necessary. In most of these cases, as we have shown in previous discussions of this subject, with the removal of intrathoracic mass which is dislocating and compressing the trachea, the natural resiliency of the tracheal ring will permit it to spring open and later roentgenograms in these cases have demonstrated that such is usually the case.

There will, however, be occasional cases, as the recent one operated on and shown in Figure 48, in which, because of an associated hyperthyroidism, together with retardation of the action of the vocal cords and the expected degree of edema of the larynx secondary to the removal of such an intrathoracic goiter, there was a question as to whether or not the patient would be able after operation to obtain an adequate intake of air. In this case there was the added factor of hyperthyroidism and already such difficulty in breathing that we did not dare to wait to bring the metabolic rate to normal because of the fear that the respiration was being progressively obstructed and the patient might require an emergency tracheotomy before the subtotal thyroidectomy could be done. The combination of factors of marked narrowing of the trachea, retardation of cord action, increasing tracheal pressure, and the need for immediate removal of the intrathoracic adenoma because of these symptoms, before the secondary hyperthyroidism could be controlled, is an indication for tracheotomy, and such an operation was immediately done upon this patient upon removal of the adenoma from the chest. One should, when there is any serious doubt about the ability of the patient to obtain an adequate amount of air intake postoperatively, do the deliberate tracheotomy at the time the subtotal thyroidectomy is done rather than permit the patient to go through the hazards of the determination for a postthyroidectomy tracheotomy when the risk would be infinitely greater.

A roentgenogram and photograph (Figs 48 and 49) of such a patient show the degree of obstruction and the tube in place. This tube was removed in eleven days.

Still another type of tracheotomy must frequently be done, and we have spoken of it in almost all of the articles we have ever written concerning the surgical and radiologic treatment of cancer of the thyroid, that is, the tracheotomy which is done on patients with extensive cancer of the thyroid when but a part of the thyroid carcinoma can be removed.

Tracheotomy is not a problem in early carcinoma of the thyroid involving but one lobe or a part of a lobe, but it does arise with patients who have fairly advanced carcinomas of the thyroid involving both lobes. We have, for a long time, stated that we have not been interested in total thyroidectomy for this type of carcinoma. These growths are frequently fixed, one side frequently extends into the mediastinum, and they are frequently fused with the trachea and total

removal would accomplish very little good in terms of getting all of the thyroid malignancy out and would in many cases result in bilateral abductor paralysis, tetany, and even esophageal fistula in some of the cases. In such patients, with bilateral carcinoma for whom the best results may be achieved by roentgen radiation, one entire lobe and the entire isthmus of the thyroid are removed a a first step in the procedure. The trachea is coincidentally exposed throughout it length, and an immediate tracheotomy performed.



Fig. 48.



Fig 49.

Fig. 48. In this illustration are shown the deviation and narrowing of the trachea in whic because of the associated hyperthyroidism and retardation of cord action, a prophylacti tracheotomy was done.

Fig. 49. The tracheotomy tube is resting comfortably without tilting because the openin in the trachea has been made at a lower level than the skin incision. Note the cigarett drain in the mediastinum emerging from the left angle of the wound.

The need for tracheotomy has been based upon the fact that if one attempt to irradiate a bilateral thyroid cancer with the trachea unexposed, such will b the degree of postoperative reaction, edema and compression of the trachea tha an emergency tracheotomy will frequently have to be done through the unre moved malignant thyroid tissue over the isthmus. This can be accomplished onl with great technical difficulty and with a much added hazard of losing th patient.

If, in such cases, the entire lobe on one side, together with the entire isthmu is removed and the trachea completely bared and then a tracheotomy is pe formed, any degree of roentgen radiation may be carried on safely without th danger of difficulty with obstruction to breathing.

There is still another warning that we would like to urge upon all surgeon operating upon patients with any type of thyroid disease and that is, if a previou thyroid operation has been done before the patient comes for further surgery

and unilateral abductor paralysis has occurred in this previously performed thyroid operation, we know that that patient's glottic space has been materially cut down. A much closer watch must be kept on patients with unilateral abductor paralysis for a possible need for tracheotomy than when cords are functioning normally because a small amount of added edema can so diminish the already narrowed glottic space in these patients that a tracheotomy will frequently be necessary.

If, in such a case with a unilaterally injured nerve and fixed cord, there is any degree of tracheal narrowing from a later enlargement of the thyroid on the opposite side, and this must be removed, and there is any question whatever of the ability of the patient immediately after operation to get in an adequate amount of air, a temporary tracheotomy should be done as soon as the operation is completed rather than take the chance of having to do it later as an emergency.

We believe that many surgeons lacking a large experience with thyroidectomy patients have been apprehensive that if the mediastinum has been opened as in intrathoracic goiter, or if the neck has been widely exposed, the doing of a tracheotomy will add greatly to the possibility of a mediastinitis or fascial plane infection. Such has not been our experience. We have had no hesitancy whatever in doing tracheotomies when they were indicated in patients who have had large intrathoracic goiters removed, leaving behind large mediastinal cavities. It is to be remembered that most intrathoracic goiters, if removed within their line of cleavage, have a well-established layer of condensed connective tissue about them. If these cavities and the fascial planes are packed loosely with gauze at the time of the tracheotomy, one does not have to fear a fascial plane infection or mediastinitis.

A final warning which we wish to make concerning patients with postthyroid ectomy difficulty in breathing is that patients with cardiac damage endure even moderate degrees of postthyroidectomy obstruction much less well than do patients with normal heart capacity, and the need for even closer watching and earlier postthyroidectomy tracheotomy is much more seriously urgent in these cases, if such can be possible, than in patients with normal hearts presenting this problem.

THE TRACHEOTOMY

The primary purpose of a tracheotomy is to produce an adequate free breathing space below the obstruction, that is, to relieve the patient in respiratory distress, caused by an insufficient airway. The second purpose is to maintain this airway until the obstruction is relieved. This maintenance of the airway includes the care of the tracheotomy tube itself and the removal of secretions from the tracheobronchial tree which may obstruct the airway below the tracheotomy tube.

On examination of an obstructed patient if the signs are advanced, such as retraction of the supraclavicular fossae or rib interspaces, or if the patient is cyanotic and the respirations labored, there is no question concerning the need for tracheotomy. In the less advanced cases, however, and the patients should be seen in this stage, an audible stridor may be present and the examination of the chest may reveal râles and rhonchi throughout due to accumulated secretion which the

patient is unable to expel. Indirect laryngeal examination at this time reveals the size of the airway through the larynx and upper trachea, and it also gives information as to the action of the vocal cords. From these observations additional information may be obtained upon which to base a decision for or against immediate tracheotomy.

Test of Treatment

A test of treatment consists of the elevation of the patient's head, the humidification of the air by steam inhalations and the administration of expectorants which may help in the elimination of secretions, the use of suction and the aspiration of secretions, having the patient cough and placing the patient in an oxygen tent.

If such treatment does not restore the patient's color and make it possible for him to sleep, a tracheotomy should be done. However, if there is relief to the extent that the patient is able to sleep and is of good color, tracheotomy may be withheld.

Performance of Tracheotomy

The opening in the trachea should be placed at least below the first ring of the trachea, and even better, below the second tracheal ring or lower. It is extremely



Fig. 50. Note the properly placed tracheotomy tube resting in the trachea at the right angle.

important that the tracheotomy tube should not lie in contact with the cricoid cartilage. It is important also that the incision into the trachea not be made through the cricoid cartilage. Pressure of a tube against the cricoid cartilage at times produces a cricoid perichondritis. The cricoid cartilage encircling the larynx,

if so affected, may produce an infiltration and edema which extends entirely around the larynx and even a part of this basic cartilage of the larynx may be lost

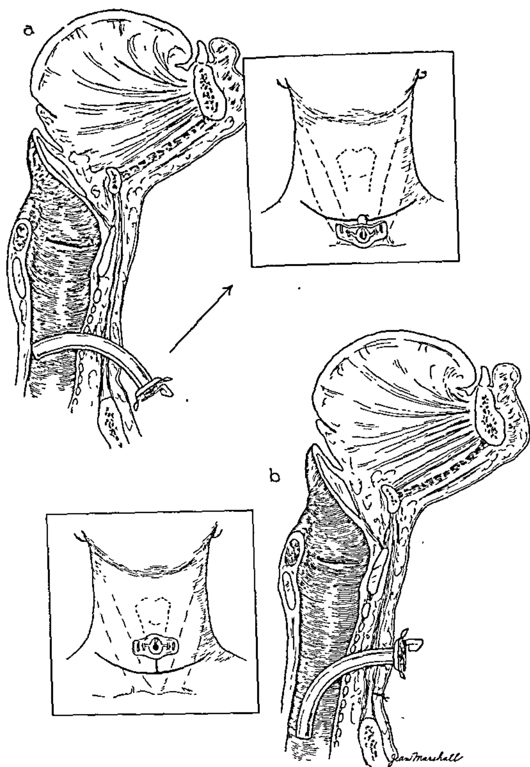


Fig 51. For purposes of better illustration, in *a* is shown diagrammatically the improperly placed tube and in *b* the properly placed tube through a longitudinal incision in the scar.

and a very troublesome cicatricial stricture of the larynx result, making permanent removal of the tube impossible. This disturbing complication may be avoided by placing the incision through the tracheal rings at a lower level.

A second extremely important and much neglected point in the performance of a tracheotomy which is carried out through the previous thyroid incision is the relative position of the opening in the trachea to the skin incision. The tracheal opening for the tracheotomy tube must be at a lower level than the opening in the skin through which the tube must pass. Should the skin incision for the thyroid operation be low, it is necessary to make a second short skin incision perpendicular to the first which permits the tracheotomy tube to lie freely in the correct position, that is, with the tracheotomy tube passing through the skin at a higher level than the point at which the tube enters the trachea (Figs. 50 and 51, *b*). If the opening into the trachea is made at the same level as the skin incision, there will be pressure by the tissues above the incision against the tube, which will thus bring its lower end against the back wall of the trachea. Such a



FIG. 52. Note the improper position of the tube with its external portion tilted downward owing to the fact that it has been placed in the trachea at the same level as the skin incision.

position interferes with the airway and produces undesirable ulceration and irritation of the tracheal wall (Figs. 51, *a*, and 52).

The tube selected must be large enough to provide an adequate airway for the individual. Ordinarily, a No. 5 tube is used for women and a No. 5 or No. 6 tube for men. Larger or smaller tubes may be used to advantage in special instances, depending upon the size of the patient, smaller tubes being used in children.

In occasional cases, a tracheotomy tube of extra length may be necessary in order to reach below the narrowing of the trachea which occurs in the superior mediastinum when mediastinal extension of a goiter has taken place. In all operating rooms in which patients with goiters are operated upon in any numbers, tubes of this type should be at hand ready and sterilized

When there is any question as to whether or not the tube reaches below the level of the tracheal obstruction, checking of the tube and its position by roentgenologic examination of the trachea in both the anteroposterior and lateral posi-

tions gives valuable information concerning the relation of the tube to the trachea and to the area of tracheal obstruction.

In order to decrease contamination of the thyroid wound we have found the following tracheotomy technic helpful. A round opening, slightly smaller than the tube to be introduced, is made in the trachea. The tracheotomy tube will then fit snugly into the trachea, air and secretions will not escape about the tube to contaminate the wound, and serum and blood from the wound will not enter the trachea as occurs when a larger opening into the trachea is made. If care is taken as to these details, the wound will be kept much cleaner, since during coughing the secretions will be expelled either through the larynx or through the tracheotomy tube rather than into the open thyroid wound. With this precaution there is also much less likelihood of the occurrence of subcutaneous emphysema.

At the time of tracheotomy, a drain of gauze is placed about the tracheotomy tube from the tracheal opening to the skin surface and the wound may then be closed quite closely about the tracheotomy tube.

The outer tracheotomy tube is usually left in this position for a period of four to five days before it is changed, and the drain about the tube may be removed at the first changing.

The regular removal of secretions from the tube and trachea is most important and, in addition, the secretions must be prevented from drying and crusting in the tracheal tube and in the trachea and bronchial tree. To accomplish this, an adequate suction apparatus must be at hand to remove these secretions and adequate nursing care must be available. It is extremely important that secretions be wiped away from the tube or removed by suction when they are coughed out rather than to permit them to be blown and sucked back and forth through the tube during respiration. To prevent drying, humidified air is very helpful and, in addition, saline solution alone or with a small amount of sodium bicarbonate and, when indicated, saline containing antibiotics may be introduced directly into the tracheotomy tube by an atomizer or dropper. It is extremely important that the dropper have an extension of a small rubber tube upon its tip because of the danger of the tip of the glass medicine dropper being broken off in the tracheotomy tube and a troublesome intratracheal foreign body problem resulting.

It must be impressed upon the nurse in attendance that the tracheotomy tube is vitally important to the patient and the patient's life depends upon its care. When the inner segment of the tracheotomy tube is taken out for cleansing, it must be cleansed immediately and returned; otherwise secretions may dry in the outer tube and it may be impossible to restore the airway without taking out the entire tube. It must be firmly impressed upon the nurse in charge of a patient with a tracheotomy tube in place that if difficulties arise which she cannot solve within a very short time by herself, she must call for experienced help rather than postpone the call until an urgent emergency has arisen. For example, if there is noisy breathing after the aspiration or suction of secretions from the tube and after cleansing the tube, since this procedure should completely relieve the patient of his noise or breathing distress, the surgeon in charge should be called at once He should investigate by opening the wound as much as necessary, by removing the tracheotomy tube, inspecting the trachea and, in some instances, even using the bronchoscope to remove plugs, crusts or hardened secretions, if

they have been allowed to accumulate. Under proper care this seldom happens, but it is always a possibility and must be kept in mind.

Other occasional temporary dysfunctions of the larynx and esophagus may occur following thyroid surgery and tracheotomy, such as dysphagia and incontinence of the sphincteric or valvular action of the larynx during swallowing. Food and fluids may pass through the larynx into the trachea. As a result, coughing and choking with the expulsion of fluids and food particles through the tracheotomy tube take place. This condition may readily be recognized and all fluids and food withheld to prevent injury and infection of the bronchial tree and lungs. Feeding by Levin tube or fluids parenterally is, under the circumstances, carried on until the larynx regains its valvular function.

When and how shall the tracheotomy tube be removed? Briefly, one may say that the tracheotomy tube may be removed as soon as an adequate airway through the larynx and trachea has been re-established. The re-establishment of the airway may be tested by plugging the tracheotomy tube with a corner of a large gauze sponge packed into the tube. If the patient is comfortable and can sleep with the plug in the tube, then there is an adequate airway. In addition, indirect laryngeal examination should be made and if there is motion of at least one vocal cord, the tracheotomy tube may then be removed. It is to be remembered that as the result of the postoperative edema there will occasionally be temporary immobility of the cords.

When the larynx is adequately open and the obstruction lies low in the trachea, the tracheotomy tube may be large enough to obstruct the trachea; that is, the breathing space around the tube or between the tracheal tube and the tracheal wall is not adequate. In such cases it is necessary to replace the larger tube with one of smaller size so that the patient may breathe around the tube or both around and through the tube. Later, a tube small enough to permit breathing about it and yet large enough to maintain an opening between the skin and the tracheal opening can be plugged to test the patient's airway.

CONCLUSIONS

Four types of tracheal obstruction in patients having thyroidectomy performed are discussed: the slowly increasing obstruction from edema of the larynx, the rapidly increasing obstruction from arterial or venous hemorrhage, the type with tracheal compression from intrathoracic goiter and the type in patients with cancer of the thyroid in which tracheotomy is done as a prophylactic means.

The indications for tracheotomy in these four conditions are discussed.

The methods of doing tracheotomy in these cases are discussed and illustrated, and the indications for the safe removal of the tracheotomy tube are stated.

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TUMORS OF THE SUBMAXILLARY AND PAROTID GLAND AREAS

SAMUEL F. MARSHALL AND GEORGE O. MILES

INTRODUCTION

Since Virchow described mixed tumors of the parotid in 1863, much has been written about salivary gland tumors. These tumors, though not common, are far from rare; their incidence is given as 1 to 2 per cent of all tumors. Interest in this group has probably far exceeded their frequency of occurrence. This is the result of the fact that pathologists and surgeons are still not in full agreement about the histogenesis, classification and treatment of these tumors. The pathologist in selected cases has great difficulty in cytologic interpretation; the surgeon in many cases has a difficult decision to make regarding surgical management. For this reason, this study of 150 tumors of the parotid and submaxillary region has been undertaken. We have included 16 cases in which the growths were not histogenetically tumors of the salivary gland but tumorous swellings in the parotid and submaxillary areas; likewise, 28 salivary gland tumors occurring in other than the parotid and submaxillary areas were excluded.

Although tumors of the salivary gland are much more common in the parotid and submaxillary areas, they also occur in the oral cavity, nasopharynx, accessory nasal sinuses, lacrimal gland, and middle ear. In these regions the salivary gland tumor arises from the mucous glands of the mucous membrane covering the lips, alveoli, buccal surface of the cheeks, tongue, palate, pharynx, and upper respiratory passages. In these locations the tumors are often referred to as of aberrant salivary gland origin, which is a misnomer since they arise not from aberrant structures but from constant anatomical components of the mucous membrane.

Table 1 lists the material reviewed in this report. It is noted that 100 benign mixed tumors are included. The 24 cases of cancer of the salivary gland form only 18 per cent of the true salivary gland tumors presented in this group. This proportion of cancer is somewhat lower than that given by some writers who report an incidence as high as 50 per cent.

Only 5 cases of adenolymphoma, also known as papillary cystadenoma lymphomatosum or oncocytoma, are included.

Four of the 24 malignant tumors are lymphoblastoma in origin. This pathologic entity may occur primarily in lymph nodes of the salivary glands or may present in these regions as part of a generalized neoplastic process. This possibility must always be considered in the differential diagnosis of an apparently mixed tumor of the parotid and submaxillary gland.

The one case of neurofibrosarcoma of the facial nerve within the parotid

Revision of article originally published in Surgical Clinics of North America, 27:501–516 (June) 1947.

gland is a rare tumor. This patient had nine operations over a period of ten years. The pathologic report was neurofibroma in all but one specimen, which showed neurofibrosarcoma. The last year that she lived, a rapidly growing, ulcerating tumor, 8 cm. in diameter, was observed eight months after she had been clinically without evidence of disease.

The group of tumors arising in the submaxillary gland is small and the only malignant process among this group is Hodgkin's disease. One possible reason for infrequent malignant tumor in this group is that the average duration of the

Table 1. Classification of Tumors in This Group

1. Parotid		
A. Benign		94
a. Mixed tumors	89	
b. Adenolymphoma	5	
B. Malignant		23
a. Adenocarcinoma	8	
b. Malignant mixed tumor	9	
c. Epidermoid carcinoma	2	
d. Lymphosarcoma	2	
e. Hodgkin's disease	1	
f. Neurosarcoma	1	
2. Submaxillary		
A. Benign		11
a. Mixed tumors	11	
B. Malignant		1
a. Hodgkin's disease	1	
3. Miscellaneous Tumors		18
A. Parotid cyst	2	
B. Branchial cyst in parotid gland	1	
C. Angiomas	3	
D. Sarcoid	1	
E. Pre-auricular sebaceous cyst	1	
F. Submaxillary inflammation	4	
G. Submaxillary inflammation with calculi	6	
4. No Pathologic Diagnosis		3
Total		150

submaxillary tumors before the patient came to operation was three and one half years, in only 2 patients was the tumor present over five years; in these two cases the tumor was present seven and nine years, respectively. This duration may be compared with that of the 89 benign parotid tumor group whose average duration before operation was eleven years; in 22 cases, or 24 per cent, the tumor had been present from sixteen to forty years before the patients came to surgery at the clinic.

The miscellaneous group of tumors is of interest chiefly as a problem of differential diagnosis. The preoperative diagnosis, with the exception of the 10 cases of inflammatory submaxillary gland, was parotid tumor. The majority of parotid tumors is easily identified. If the physical findings are not typical, however, one should consider in the differential diagnosis other tumorous swellings that are known to have mistakenly been called parotid tumors. Two of the three angiomas in this group were deep-seated angio-endotheliomas which may appear

as firm masses in contrast to the cystic consistency of the more common cavernous variety. The other occurred in an infant of 2 years at which age angioma should always be considered in examination of any deep-lying mass in this area. The sebaceous cyst in this group was described as a firm, fixed, pre-auricular mass, possibly carcinoma. Sebaceous cysts are frequently seen in this region, and usually present themselves as obvious intradermal cysts. The branchial cleft cyst reported in this area developed through the substance of the parotid gland. This presenting site for branchial cleft cyst has long been recognized but must be rare from its infrequent occurrence in reports on branchial cleft series. The parotid cysts noted in this group are presumably associated with inflammation and obstruction. Ranula, occurring in the floor of the mouth and associated with inflammation of the submaxillary gland, is a common example.

Parotitis is the most common non-neoplastic swelling confused with parotid neoplasia. The surgeon should be suspicious of the typical mixed tumor, 3 cm. in diameter or larger but of only a few weeks' duration. Parotitis is usually tender to palpation, which is the most important differential sign; however, when the patient is seen twenty-five or more days after its onset and when the inflammatory process has become chronic and fibrotic, it may not be tender and may appear to the examiner to be a typical parotid tumor. Such inflammation may be low grade from the onset. When the surgeon recalls that parotid tumors not infrequently present beneath the pinna of the ear in the space between the angle of the mandible and the mastoid process, he must consider in the differential diagnosis other tumors that occur in this area. Hyperplastic and tuberculous adenitis, sarcoma, metastatic carcinoma, branchial cleft cyst, schwannoma, and lipoma may occasionally suggest submaxillary or parotid tumors. Eight of the benign mixed tumors of the parotid in this series had at some time been regarded as hyperplastic adenitis before the patients came to the clinic; 2 of these patients had had, respectively, a tooth extraction and tonsillectomy; one of the patients with parotid carcinoma had had a tonsillectomy when a physician was first consulted because of the appearance of the lump beneath the angle of the mandible. One of the frequent features of sarcoid is parotitis that on more than one occasion has been thought to be a parotid tumor.

The following discussion will be directed chiefly toward the true benign and malignant salivary gland tumor of the parotid and submaxillary gland.

INCIDENCE

Of this group, 99 were females and 51 were males. The left parotid and submaxillary glands were affected in 84 and the right side in 66. The average age of the 100 patients with mixed tumors at operation was 45.0 years. The average age of the miscellaneous group was 51 years. The average age of the patients with adenolymphomas was 61.4 years. It has been pointed out that adenolymphoma is more common in men in the fifth and sixth decades of life. Three of our 5 patients were women.

Of 88 patients with benign mixed tumors who gave some statement relative to the onset of disease, the average age was 34.3 years. The average time that elapsed before operation was 10.6 years. Table 2 shows the duration of mixed tumors in this group. Table 3 shows the age at onset in 88 patients according

to decades of life compared with the age at operation of 100 patients with mixed tumors. Of this group 83 per cent had tumors before the age of 50. Only 59 per cent of the group were operated on before the age of 50.

Of the 24 cases of malignant tumor, 23 patients gave statements about the

Table 2. Duration of Mixed Tumors

Less than 1 year	12
1– 5 years	25
6–15 years	29
16–26 years	12
Over 26 years	10
Not stated	12

appearance of their disease. The average age at onset was 48 years; the average age at operation was 54.5 years and the average duration of tumor before operation was 6.6 years. If the patients with lymphoblastomas whose duration

Table 3. Age at Onset Compared with Age at Operation

	APPEARANCE	OPERATION
0–10 years	2	0
11–20 years	17	6
21–30 years	17	11
31–40 years	19	21
41–50 years	18	22
51–60 years	12	21
61–70 years	3	17
71–80 years	0	2

was three months, five months, eight months and nine years, respectively, were not included, the time elapsed before operation for this group would be even higher. The duration of tumor in the malignant group is shown in Table 4.

Table 4. Duration of Malignant Tumors

Less than 1 year	10
1– 5 years	5
6–15 years	4
16–26 years	4
Not stated	1

Table 5 shows this group in age decades at time of onset of tumor and operation for carcinoma.

Many patients, in explaining delay of treatment of these tumors, tell us that they thought "if it wasn't bothering them they wouldn't bother it." This adage is frequently abused by both the patient and physician in regard to parotid and submaxillary tumors. The statement has also been made that all mixed tumors of the salivary gland are potentially malignant. From the foregoing tables one might also state that they are the most neglected. The patients with carcinoma come to surgery sooner, presumably because 35 per cent of the group noted rapid

growth upon first appearance. Sudden increase in rate of growth preceding operation was noted in several of the carcinomas and mixed tumors that had been unchanged in size for years.

Table 5. Age at Onset Compared with Age at Operation

	TUMOR APPEARED	OPERATION FOR CARCINOMA
0–10 years	0	0
11–20 years	3	1
21–30 years	1	0
31–40 years	5	4
41–50 years	6	6
51–60 years	3	6
61–70 years	3	3
71–80 years	2	4

PRESENTING SYMPTOMATOLOGY

In reviewing records in an effort to evaluate symptomatology, there are, no doubt, many errors of omission. One may note only the most significant points. Table 6 depicts only generalities in analysis of presenting symptoms.

Excluding the miscellaneous group, 85 histories of patients with benign tumors gave some information relative to the rate of growth. Of these, 8 patients complained of rapid growth from the time a lump was noted. Of the malignant group, 19 histories furnished statements regarding growth; of these, 7 patients complained of rapid growth from the time a tumor was first noted.

A large number of patients had had previous operative procedures before appearing at the clinic. The best chance of complete removal of a benign or malignant tumor in these areas with the smallest incidence of facial nerve injury and recurrence is at the first operation. Two patients with mixed tumors of the submaxillary gland, 1 patient with mixed tumor of the parotid gland, and 1 with adenolymphoma had incision and drainage before coming to the clinic. Two patients with mixed tumor of the parotid had a tonsillectomy and tooth extraction, respectively, for hyperplastic adenitis; 1 patient with carcinoma of the parotid had a tonsillectomy for hyperplastic adenitis; 5 patients with inflammatory submaxillary glands had one or more incisions and drainage before we saw them, and another patient in this group had a tooth extraction for hyperplastic adenitis. Of the total group, 20 patients had had one or more previous excisions of tumor before coming to the clinic.

The symptom of pain was mentioned by one third of the patients with carcinoma but by only 16 per cent of the patients with benign noninflammatory disease. In general, the patients with benign processes who had any discomfort had large tumors.

Only 2 of our patients with parotid carcinoma noted paralysis before they discovered a tumor; 1 of these patients presented marked weakness of facial musculature when seen. Another had had facial paralysis on two occasions which lasted weeks and disappeared; he presented only paralysis of the mandibular branch of the seventh cranial nerve when seen. More unusual than this, however, is a patient with adenolymphoma of the parotid gland who came in with

Table 6. Presenting Symptoms

	SLOW OR NO INCREASE IN SIZE	NO CHANGE FOLLOWED BY RAPID ENLARGEMENT	RAPID INCREASE IN SIZE	PREVIOUS OPERATION WITH RECURRENT OR RESIDUAL TUMOR	PAIN	TRAUMA	PRESENTING FACIAL PARALYSIS; NO PREVIOUS OPERATION	PRESENTING FACIAL PARALYSIS IN RECURRENT CASES	TRISMUS	CAME TO CLINIC FOR OTHER REASONS
Mixed tumor of parotid	47	18	7	25	12	4	0	2	4	11
Mixed tumor of submaxillary ..	7	1	0	1	0	0	0	0	0	2
Malignant tumor of parotid	2	7	9	5	6	2	2	2	2	0
Malignant tumor of submaxillary	0	0	1	0	0	0	0	0	0	0
Adenolymphoma	3	1	1	1	0	0	1	1	0	1
Miscellaneous tumors	11	0	9	7	7	1	0	0	0	3

paralysis of the mandibular branch of the facial nerve, with no history of previous operation. This branch was identified and preserved during operation, and the patient, after two months of continued droop of the angle of the mouth, eventually obtained complete restoration of function of this nerve. There were 4 patients with complete facial paralysis following operation elsewhere; 2 had malignant tumors and 2 had benign tumors of the parotid gland. Of the 6 patients who had limitations of temporomandibular joint motion or trismus, only 1 had not had previous operation. In this series, as noted in Table 6, there are several patients who came to the clinic with other complaints but who eventually came to surgery after their tumors were discovered by the examining physician.

Upon examination, fixation of the tumor is the most presumptive single physical sign of carcinoma; likewise, if the tumor is freely movable it suggests benign tumor. Table 7 shows the number of patients with parotid tumor whose case records contained a statement regarding mobility or fixation.

Although fixation or mobility may be of presumptive importance concerning the nature of the tumor, it is more important to note that this tumor, as others, may present differently regardless of its nature. Consistency and discreteness of the mass likewise are not reliable in estimating the type of tumor.

It is interesting from a medicolegal standpoint that 7 patients associated the appearance of their tumors with preceding trauma. Many individuals seek an explanation for disease of any type. That they know nothing of fundamentals in speculating as to the *modus operandi* is not a deterring factor.

Table 7. Mobility and Fixation in Parotid Tumor

PAROTID	FIXED	MOVABLE
Benign	8	39
Malignant	10	6

There is no group of tumors in which some patients are not convinced of the relation of preceding trauma. That such a history is more frequent among patients with peripherally located tumors as in the parotid and submaxillary gland is to be expected. The physician should be aware and anticipate such situations in order to advise patients correctly. There is no positive evidence of any relation between single trauma and the appearance of tumors in this region.

RECURRENCES AND FACIAL NERVE INJURY

We are not able from our records to make a study of recurrences or facial nerve injury in relation to the size of the tumor. We cannot accept the conclusions of McFarland[7] that small tumors are more likely to recur after operation than are large tumors. If excision of small tumors is undertaken by those of limited experience and large tumors by the more experienced surgeons, the results might suggest such an observation.

Recurrences following excision for benign tumors of the parotid gland are reported by several groups[5] (Table 8). Surgical excision must be performed technically, with two foremost considerations. A liberal margin of normal sali-

vary gland should be removed with the tumor to avoid recurrence. Injury to the facial nerve is to be avoided. If the margin of normal gland removal is too liberal there is increased danger of injury to the facial nerve. One may, however, avoid facial nerve injury to such an extent that residual tumor remains. Excision of tumor with an adequate margin of adjacent normal salivary gland with preservation of the facial nerve is best accomplished by early isolation and identification of the nerve in all but the most superficially located tumors.

Several other factors influence recurrence of these tumors. Whereas some of the tumors have fairly thick capsules, favoring complete removal by close dissection, others have thin capsules which are more likely to be broken during excision. Spilling of the tumor tissue in the wound will favor recurrence. In the operative notes of the records reviewed in this series, tumor spilling is described in 15 cases. Benign mixed tumors are also known occasionally to penetrate their capsules, in which case pericapsular dissection is likely to leave tumor cells in the wound. Some writers describe such penetration through the capsule by benign tumors, but such infiltration is more probably confined to

Table 8. Frequency of Recurrence

	PER CENT
McFarland[7]	25
Benedict and Meigs[4]	42 5
Wood[10]	45
Stein and Geschickter[9]	20
Ahlbom[2]	20–25 (within 3 years)

cancer. The presence of carcinoma increases the chances of local recurrence. The margin of excision of normal tissue beyond the carcinoma may be the factor which determines whether cure or recurrence results. Operations for recurrent benign tumors of the salivary gland are less likely to result in the successful complete ablation of the tumor, and are technically more difficult than operations on patients who have not had previous surgery. Recurrence of carcinoma of a salivary gland inevitably results in failure to cure the disease.

Although recurrences of benign tumors of the salivary gland have been reported as late as forty-seven years after excision, the majority of these recur within five to seven years. McFarland has *given the average time* of recurrence as 7.2 years for benign parotid tumors. Of the 21 patients who came to the clinic with recurrent mixed tumor, 3 had their recurrence eleven, eleven and nine years, respectively, following excision. One had noted a recurrence four years after excision. The remaining 17 had noted their recurrences in less than three years after operation and a few stated they had noted evidence of tumors postoperatively.

Recurrences are much more frequent after excision of carcinoma of the salivary gland. Despite the fact that some of these tumors present as grossly localized superficial tumors, we can find no satisfactory or encouraging report in the literature on results of treatment of this disease. Although our results are poor, we believe we are improving the handling of this problem. We cannot find in *the literature a study of parotid carcinoma, stating how many of a series were*

excised on the assumption that they were benign, the operative procedure performed, and the report subsequently revealed a carcinoma. Our charts do not give such information in this series. We believe many failures in parotid carcinoma surgery are the result of such a sequence of events. It is our belief that when more of these tumors are approached in the manner which is to be discussed, the recurrences and surgical failures will be lessened.

Table 9. Recurrence

WITH 5 YEARS OR LONGER FOLLOW-UP	NO RECURRENCE	SUBSEQUENT RECURRENCE	RECURRENCE, PER CENT
Benign parotid or submaxillary tumor, no previous surgery (13 patients)	11	2	15
Recurrent benign parotid or submaxillary tumor (2 patients)	1	1	50
Parotid or submaxillary carcinoma (10 patients)	1	9	90
Recurrent parotid or submaxillary carcinoma (4 patients)	0	4	100

Recurrences are more frequent in certain histologic patterns than in others. To divide the many variations of this malignant tumor into only three groups, as we have in Table 9, does not represent its scope of presentation. Epidermoid cancer and adenocarcinoma give in general a less favorable prognosis than malignant mixed tumors. The variations within these groups necessitate a consideration of the histologic pattern in the prognosis. The management of this problem calls for a surgical approach that will provide removal of wide margins of normal tissue together with the tumor without injuring the seventh cranial

Table 10. Damage to Facial Nerve by Surgery of the Parotid Gland

	TOTAL, PER CENT	BENIGN PER CENT	MALIGNANT, PER CENT
Benedict and Meigs	13 7	7.5	20.0
Stein and Geschickter		10.0	
McFarland	4.4		
Ahlbom	16.9	11.0	36 6
Marshall and Miles	14.5	10.6	30.4

nerve. Table 9 presents results of accurate follow-up from the standpoint of recurrence in only a small group of this series. We are in the process of obtaining accurate follow-up data in this entire group for later publication.

We have analyzed our incidence of facial paralysis in those patients having only paralysis of the mandibular branch and those having complete paralysis. The figures shown in Table 10 include all cases of minimal and intentional nerve sacrifice. Our incidence of facial paralysis has been greater in patients with recurrent tumors, benign or malignant, than in those having no previous surgery. Facial paralysis is more frequent following operative procedures for carcinoma, in which case secondary branches are readily sacrificed if they traverse the tumor bed, we do not hesitate to sacrifice the main trunk of the nerve if we are

excising carcinoma through which the main trunk of the nerve runs. In 1 of our 3 cases of benign tumor with complete facial paralysis, we were unable to obtain a specimen taken at previous operation, at which time a diagnosis of carcinoma had been made. The association of nerve and tumor dictated sacrifice of the nerve. In another, the surgeon was convinced at the operating table that he was dealing with carcinoma. This latter case brings up the situation which in our opinion is the only one warranting cutting into the tumor bed for a biopsy specimen. Routinely, we make every effort not to enter the tumor bed. When a decision has to be made whether the main trunk or upper secondary branch has to be sacrificed, a pathologist's opinion of the type of the tumor may give presumptive reason for removal of the nerve. In 3 of the 4 cases of complete paralysis following surgery for carcinoma, the nerve was demonstrated to enter the tumor, and a decision was made to sacrifice it.

There is great difference in morbidity in cutting the lower and upper divisions of the main trunk of the nerve. One does not hesitate to cut the mandibular branch of the facial nerve for benign disease if saving it necessitates opening the tumor widely in the operative wound, perhaps leaving islands of tumor cells remaining, and thus endangering chances of complete excision. Nor should one hesitate to sacrifice any part of the nerve in cases of carcinoma if the nerve definitely traverses the tumor. Our one case of persistent paralysis of the periorbital muscles but intact mandibular branch of the nerve in a case of mixed tumor with no previous operation is included in the group with complete facial paralysis. Further analysis of facial paralysis in this group is shown in Table 11.

Table 11. Facial Nerve Injury after Parotid Surgery in Lahey Clinic

	MANDIBULAR BRANCH PARALYSIS		COMPLETE AND CRANIAL NERVE PARALYSIS	
	Recurrent Tumor	No Previous Surgery	Recurrent Tumor	No Previous Surgery
Mixed tumor	3 of 18 16.6%	4 of 74 5.4%	1 of 18 5.5%	2 of 74 2.7%
Carcinoma	1 of 4 25%	2 of 19 10.5%	1 of 4 25%	3 of 19 15.8%
Adenolymphoma	0	0	0	0

In addition to the facial paralysis in our operative series, there were 4 patients with facial nerve paralysis, in 1 complete, who had recurrent parotid tumors. In 2 of these, paralysis occurred following operation for mixed tumor; in 1 there was complete permanent injury of the facial nerve. In 2 cases, paralysis occurred following operation for carcinoma of the parotid, in 1 of which it was complete. Interesting also are the 2 patients with carcinoma and 1 with adenolymphoma who had paralysis of the facial nerve as a part of the onset of the disease and who had not had previous operation.

TREATMENT

Tumors of the parotid and submaxillary areas are primarily surgical problems. The possibility of cancer should always be considered in all tumors of this

region. The surgical problem is that of completely excising the neoplasm and avoiding unnecessary injury to the facial nerve. The lack of appreciation of the possibility of cancer and the fear of injury to the facial nerve have contributed to the surgical failures in this problem.

Sistrunk,[8] in 1921, and Adson,[1] in 1923, described methods of surgical approach (Fig. 53) by identification and preservation of the facial nerve, thus enabling the surgeon to excise tumors of the parotid area more adequately. In each

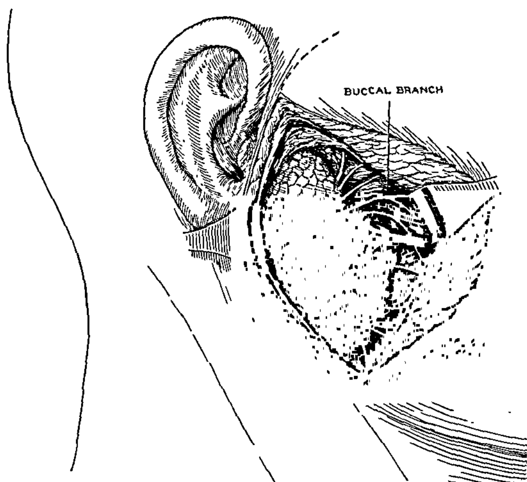


Fig 53. The relationship of branches of the facial nerve to the parotid gland is shown. Note the position of the buccal branch of the facial nerve in relation to Stensen's duct.

instance they recommended isolation and identification of the mandibular branch of the nerve which is followed back to the main trunk. Despite this approach, Sistrunk had several cases of partial and complete paralysis. We agree with Bailey,[3] of England, and Janes,[6] of Toronto, who advocate isolation of the main trunk of the nerve in all but the most superficial benign parotid tumors. The nerve can with only occasional difficulty be identified as it exits from the stylomastoid foramen. With careful dissection it may be followed forward and the secondary branches preserved. Although the better method of approach is usually the one the surgeon is better acquainted with, it is almost a surgical principle that in identifying any vital structure such as the facial nerve it is better to identify its largest part if it is equally accessible. The main trunk of

the nerve is readily accessible in all but the very large tumors in the region between the angle of the mandible and the mastoid process; in those, also, exposure of the main trunk can be accomplished.

In small, superficial, presumably benign tumors, a vertical incision is made anterior to the tragus of the ear. Upon dividing the skin and subcutaneous tissue, a flap is dissected anteriorly, exposing the tumor. If the tumor is small and protrudes from the periphery of the gland, it may be dissected safely from its bed with some adjacent, grossly normal salivary gland. If the tumor projects medially into the deep portion of the gland, if there is question of its benignancy, or if the surgeon is not satisfied with the presenting line of dissection because of inadequate margins or fear of injuring the facial nerve, the incision is enlarged. An enlargement is obtained that we recommend for all large parotid tumors and all that are suspected of cancer. It consists of prolonging the incision inferiorly over the posterior border of the angle of the mandible and anteriorly below the inferior border of the mandible and making another oblique incision posterior to the ear. These two join at a point directly beneath the pinna of the ear. By dissecting the subcutaneous tissue of this obtuse angle with its overlying skin superiorly, the ear is elevated. If there is fixation of the tumor to the overlying skin, the incision may be easily modified also to excise an ellipse of overlying skin with the tumor. A skin flap containing little or no subcutaneous tissue, depending on the presenting problem, is then elevated anteriorly from the surface of the parotid gland and retromandibular area. This may be carried anteriorly well beyond the parotid gland without fear of slough upon closure. In large tumors in which access to the stylomastoid foramen is blocked, and this represents only a few, the tumor can then be dislodged anteriorly. In any case, upon isolating the nerve, dissection can be carried out anteriorly, preserving the nerve, with the gross tumor mass under vision at all times. As the dissection proceeds, the operation may be altered to extensive subtotal parotidectomy or complete ablation of the gland, including the tongue of parotid gland that protrudes retropharyngeally and lies medial to the nerve. Except for this tongue of salivary gland of inconstant size, very little of the parotid gland need be traversed to excise the bulk of the gland. The nerve lies on the lateral surface of the masseter muscle after coursing through 2 cm. or less of salivary gland. The stimulating electrode used by the neurosurgeon is of great value in identifying branches of the facial nerve, and should always be employed.

Of greatest aid in dissecting for the nerve, after developing flaps and before locating the nerve as it exits from the stylomastoid foramen, is the identification and ligation of the external maxillary artery in the neck. This may be done through the submandibular portion of the incision which runs 4 to 5 cm. anterior to the angle of the mandible. This minimizes bleeding in the operative area. If the surgeon neglects this, he will be reminded of it by the vascularity he encounters in his dissection for the nerve and excision of the tumor. The few minutes required for external maxillary ligation is more than compensated for by the maintenance of hemostasis and thereby assistance in following the nerve forward.

In approaching the stylomastoid foramen for identification of the facial nerve, dissection is made within a few millimeters of the anterior surface of the mas-

toid process. The nerve lies 1 to 2 cm. medial to the lateral surface of the tip of the mastoid; it exits at a point 1 cm. superior to the tip. Its axis in the superior-inferior plane may appear inconstant owing to slight variations of position on the table in different patients. When dissecting in this region, the tendon of the digastricus, the tip of the mastoid process, the styloid process, and the transverse process of the axis are readily identified.

Anesthesia is obtained by intratracheal intubation with an inhalation anesthetic of the surgeon's choice. Intratracheal intubation is of aid not only in maintenance of oxygenation and anesthetic level but it permits proper draping of the field and access of the surgeon and two assistants to the field without interfering with the anesthetist.

If metastatic carcinoma is found in lymph nodes directly below the parotid tumor or elsewhere in the neck, radical neck dissection of tissue in continuity with the field of primary disease is done.

A cotton plug in the external auditory canal at the onset of operation aids in avoiding subsequent difficulty of removing dried spilled blood that inevitably finds its way there.

A drain is usually not necessary if a pressure dressing around the entire head is applied with elastoplast. In such application the ear should be padded to avoid pressure chondritis. In extensive subtotal parotidectomy or complete ablation of the gland, a Penrose drain left in place for three or four days will provide an exit for secretions and permit better wound healing.

As the result of excellent tissue vitality in this area, wound healing usually is good and scars often are scarcely noticeable. This is particularly true of the submandibular portion of the scar which is visible at only a few angles.

If large segments of skin are sacrificed, which is necessary only in very large ulcerating or skin-invading tumors, this region does not afford a satisfactory site for primary skin graft. Although fistula has not been a problem in our series, salivary seepage for a few days is not uncommon. This small amount of seepage is minimized by a carefully applied pressure dressing. A small salivary leak beneath a skin graft may result in its slough.

This surgical approach offers the following advantages: (1) It fulfills the surgical principle of exposure and identification of vital structures, fear of which may result in inadequate excision, and lack of respect of which may result in needless injury. A correlation is the principle of exposure of the recurrent laryngeal nerve in thyroid surgery. (2) As a result of the first advantage, excision of parotid neoplasia with adherence to fundamental concepts, or specifically, excision of adequate margins of adjacent normal tissue can best be accomplished. (3) We believe that improvement will result in the percentage of recurrences of benign disease, cures for carcinoma, and number of facial nerve injuries by the application of these surgical principles.

One may find almost any opinion he wishes to accept concerning radiation therapy for benign or malignant disease of the salivary gland. That mixed tumor is highly radioresistant is a generally accepted fact. No radiologist reports cures in any series of carcinoma of the salivary gland but much is written about regression, relief of pain, and radiosensitivity in selected cases. Carcinoma of the salivary gland in the oral cavity is notoriously more resistant than the epi-

dermoid variety. Highly undifferentiated adenocarcinoma is said to be radiosensitive; the remaining types are less sensitive. We are unable to evaluate our experience with this agent in the 11 cases in which postoperative therapy was given; 9 patients treated had carcinomas and 2 benign mixed tumors. Of the benign tumors, in 1 the capsule contained tumor cells; the other was regarded as a highly cellular mixed tumor. There was obviously the question of diagnosis.

A word of caution is appropriate regarding too vigorous radiation therapy to this region. Increased morbidity is reported in the form of ulceration, facial nerve paralysis, pain, temporomandibular ankylosis, and radionecrosis of the mandible following doses of radiation that are tolerated satisfactorily a few centimeters lower on the neck. Undoubtedly, some of this morbidity in reported cases is due to carcinoma in spite of radiation instead of radiation *per se.*

CONCLUSIONS

One hundred and fifty cases of tumors in the parotid and submaxillary regions are reviewed as to differential diagnosis, symptomatology, pathology and treatment.

Problems of delay in institution of treatment, diagnosis, and surgical management are presented and emphasized.

The incidence in this group of recurrent tumor and facial paralysis following operation is discussed.

A surgical approach is discussed which in our opinion will improve the surgical treatment of parotid tumors.

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TUMORS OF THE NECK

FRANK H. LAHEY

Tumors of the neck are important to discuss because they are not uncommon. Because of the fact that malignancy is not rare in them it is important to determine their character as early as possible; the need to know their origin and character is not far removed from that of tumors of the breast. Exclusive of the lipomas of the neck, which can occur anywhere in the neck and can usually be diagnosed by their consistency and demonstrable lobulation, there are almost no tumors of the neck which should not either be promptly biopsied or removed after discovery. I know of no tumor other than lipoma which can make one blush more for having forgotten it, in considering the diagnostic possibilities in superficial tumors.

The diagnosis of tumors of the neck can be extremely simple or so obscure as to make their final diagnosis possible only by exploration and biopsy, and since many of the malignant tumors of the neck will prove to be radiosensitive lymphomas, microscopic demonstration of this character should not be delayed. Dr. Hugh F. Hare, head of the Department of Radiology at the Lahey Clinic, has recently demonstrated[1] that of 181 patients proved to have lymphomas and regularly treated with roentgen rays, 29 per cent are alive and well over five years without recurrence, a point of no small importance in the early detection and treatment of these tumors.

To make the discussion of tumors of the neck orderly, my associates and I have always classified them into midline tumors and cysts, practically all occurring as single tumors, laterally located tumors and single and multiple tumors (Table 1).

These are the common tumors with which my associates and I have had to deal. I have omitted consideration of those conditions related to trauma, the extremely rare air cyst which the patient can blow up at will, pneumatocele, of which we have had 1 case, large esophageal diverticular sacs, which the patients can fill and demonstrate (rare), and the acute inflammatory lesions, such as deep cervical abscesses, Ludwig's angina and also the uncommon gummatous masses in the neck.

MIDLINE TUMORS AND CYSTS OF NECK

Midline tumors and cysts can be disposed of without too much discussion, since except for the occasional inflammatory submental mass and dermoid, they are related either to the thyroid itself or to the developmental descent of this gland from the back of the tongue to its normal place on the upper tracheal rings.

Of the midline cysts and tumors the most dramatic as well as the rarest is the lingual thyroid and the commonest is the thyroglossal cyst. Each is the result of

Revision of article originally published in the Journal of the American Medical Association, 138:264–274 (Sept. 25) 1948.

developmental failure, in the lingual thyroid the failure of the thyroid to descend and in the thyroglossal cyst the failure of the thyroglossal tract to close.

Lingual thyroids are supra, intra and infra in location in relation to the back of the tongue, at which point their origin is represented by the foramen caecum. We have had three of these unusual tumors, one supralingual and two intralingual thyroids, but no infralingual thyroids.

Table 1. Classification of Tumors of the Neck

Midline tumors and cysts
- Lingual goiter
  - Supra
  - Intra
  - Infra
- Thyroglossal cysts
- Pyramidal lobe
  - Hyperplastic
- Aberrant thyroid tissue along this midline tract
- Adenoma of isthmus
- Medial dermoids

Lateral tumors—discrete
- Inflammatory salivary gland swelling with stone
- Mixed tumors of the submaxillary gland
- Carotid body tumors
- Branchial cysts
- Neurofibromas
- Discrete parathyroid cancer
- Discrete metastatic nodules from the thyroid
- Discrete Hodgkin's disease
- Discrete lymphosarcoma
- Discrete primary carcinoma of neck (branchial tract origin)
- Discrete tuberculous cervical nodes
- Discrete adenomas of the thyroid
- Lipomas
- Lateral dermoid cysts

Lateral multiple tumors
- Hodgkin's disease
- Tuberculous cervical glands (multiple)
- *Multiple metastatic nodules from the thyroid*
- Multiple colloid adenomatous goiter
- Hygromas of neck

Low tumors of neck extending into mediastinum
- Intrathoracic goiter
- Fibromas of esophagus
- Virchow's glands
- Cancer secondary to carcinoma of stomach
- Cancer secondary to carcinoma of lung

There is little to be said about the diagnosis of these tumors, since their consistent location always at the same point on the back of the tongue marks them as lingual goiters. There would be *no excuse for including these rare tumors* in a discussion of tumors of the neck if it were not for the fact that, as shown in Figures 54 and 55, they show themselves as tumors of the neck by roentgenologic examination and as such must be considered in the diagnosis of tumors of the

neck. They force themselves on the patient's attention by their gradual enlargement, finally to the degree that they interfere with food intake and so demand the consideration of their removal.

Fig. 54. This illustration shows definitely the shadow of an intralingual thyroid.



Fig. 55. This illustration shows the specimen of the intralingual thyroid removed.

There are only two points to be mentioned in relation to the removal of lingual goiters. Lingual goiter usually represents all of the thyroid tissue which the

patient has. Before its removal is undertaken, the surgeon will save himself embarrassment and possible criticism by explaining this to the patient and his family and informing them that following the operation it will be necessary for the patient to take thyroid the rest of his life.

Because of the location of the lingual goiter on the back of the tongue and possible apprehension of one's ability to control the bleeding expected to occur with such a vascular tumor as a thyroid tumor is known to be, and in such an inaccessible location, the operative approach to such a tumor could be selected as through the neck, beneath the chin and through the tongue. We have had no experience with infralingual goiters of this type in which this approach might



be considered but for intralingual and supralingual goiter, the approach through the mouth will prove simple and in no way troublesome. With traction stitches on the lateral aspects of the back portion of the tongue, with an intratracheal tube in place and with the pharynx packed to prevent blood from being sucked into the lungs, these tumors can be removed through the mouth and the bleeding from them controlled without any great difficulty.

The two types of swellings in the neck related to the thyroglossal tract are the pyramidal thyroid lobe (Fig. 56) and the thyroglossal cyst (Fig. 57).

The *pyramidal lobe of the thyroid*, located as it most often is just to the left of the thyroid cartilage and, when completely developed, extending from the thyroid isthmus to the hyoid bone, will interest us as a tumor of the neck only as it occurs in patients who have had subtotal thyroidectomies performed for exophthalmic goiter in the course of which operations the pyramidal lobe of the thyroid has not been removed. Everyone who has had considerable experience with the surgical treatment of hyperthyroidism has many times seen the small pyramidal lobe of the thyroid overlooked in the thyroidectomy and not

removed. When this pyramidal lobe, preoperatively so insignificant, is not removed in the subtotal thyroidectomy for active hyperthyroidism, it can so enlarge postoperatively from hyperplasia that it can be seen and felt as an unsightly finger-like tumor mass extending from the level of the thyroid isthmus to the level of the hyoid bone and resting on the left plate of the thyroid cartilage. One cannot fail to recognize enlarged pyramidal lobes of the thyroid, because of their location and because of their firmness due to the hyperplasia and tissue regeneration in them, as the thyroid still attempts in the remaining thyroid tissue to respond to the continuing influence of the pituitary-stimulating thyroid hormone.

These tumors are often extremely disfiguring, standing out as they often do on the neck as unsightly sausage-like longitudinally placed tumors. They are easily removed by re-elevating the cutaneous flap, and in their removal it is unnecessary to remove central sections of the hyoid bone and follow them up to



FIG. 57. This is a typical thyroglossal cyst Although it appears to be in the midline, it actually is just to the left of the notch in the thyroid cartilage.

the base of the tongue, as is necessary in the removal of thyroglossal cysts and tracts.

Since the thyroglossal tract, representing the embryologic remnant of the fetal thyroglossal duct, extends from the isthmus of the thyroid to the foramen caecum on the back of the tongue at the junction point made by the circumvallate papillae, one may observe a *thyroglossal cyst* at any level between these two points, in the floor of the mouth at the level of the notch in the thyroid cartilage or at the level of the thyroid isthmus. However, the most consistent location at which these cysts occur is slightly to the left of the midline and opposite the notch in the thyroid cartilage. They are commonest in children, but can and do delay their appearance until adult life. They have often spontaneously ruptured or have been incised after infection of the cyst (Fig. 58).

We have now operated on 319 patients with these cysts and have learned, as has everyone dealing with them surgically, that, if one wishes to avoid recurrences following their removal, not only must the cyst be removed but the central section of the hyoid bone must also be removed and any continuation of the thyroglossal tract followed up to the base of the tongue and

also removed. This radical removal, first proposed by Sistrunk,[2] has never failed to remove the tract entirely and result in permanent relief of the condition in my experience. There is only one warning to be uttered in connection with this operation, and one I would not feel necessary to mention if I had not seen the unsightly results of its employment, that is, that never should the incision for the excision of thyroglossal cysts be made in the longitudinal direction, but always in the transverse direction. If made in the longitudinal direction it will result in a checkrein-like scar, which is almost impossible to overcome except by means of a free graft.



Fig. 58. This illustration shows a thyroglossal cyst which has ruptured and drained, with the granulation at the point of draining. The lower level in the midline of this thyroglossal cyst as compared with the more common level near the notch of the thyroid cartilage may be seen.

Single discrete adenomas of the thyroid can occur at any level of the thyroglossal tract, but are almost never seen outside the lateral lobes or isthmus of the thyroid gland. They are not uncommon in the isthmus of the thyroid, but are usually small here, since if they attain any size they must encroach on the lateral lobes and occupy that portion of the thyroid gland.

DISCRETE LATERAL TUMORS OF NECK

In discussing the diagnosis of discrete lateral tumors of the neck, I should like to state, as a result of my own considerable experiences with them, that it is impossible in most of these cases to do more than state one's suspicion of what the tumor will prove to be, setting down the different types of tumors and cysts that need to be considered. No one who has had much experience with removing tumors of the neck can deny that what was thought might prove to be a tense branchial cyst has turned out to be a carotid body tumor; what was thought might be a carotid body tumor has turned out to be a discrete malignant growth of parathyroid origin, a discrete metastatic nodule from the thyroid or, for that

matter, any one of the discrete laterally located tumors of the neck with the exception of discrete adenomas of the thyroid and dermoid cysts included in this list.

In discussing the diagnosis of the discrete laterally located tumors of the neck, one can only suggest the features frequently observed in connection with them and at the same time admit that, in spite of this, surprises will occur when the tumors are exposed and removed and the pathologic report returned.

An *enlarged salivary gland*, usually secondary to a calculus within the salivary duct, is not difficult to distinguish, particularly because, with one finger in the mouth and the other over the region of the salivary gland, its location beneath the angle of the jaw, characteristic shape, the history of change in size and the presence of a calculus demonstrable by the roentgenogram or palpable through the floor of the mouth will generally make it possible to be rather certain of the diagnosis.

Table 2. Discrete Lateral Tumors of the Neck

Inflammatory salivary gland swelling with stone in the submaxillary duct
Mixed tumors of the submaxillary gland
Carotid body tumors
Branchial cysts
Neurofibromas
[illegible]
[illegible]
Discrete primary carcinoma of the neck (branchial tract origin)
Discrete tuberculous cervical nodes
Discrete adenomas of the thyroid
Lipomas
Lateral dermoid cysts

When chronic enlargement of one salivary gland has existed over a considerable period of time as the result of the presence of a salivary calculus, the stone may usually be excised through the mouth from its position in the submaxillary duct beneath the mucous membrane. If this does not immediately result in diminution and disappearance of the submaxillary swelling, the entire gland should be removed externally.

Mixed tumors originating in the salivary gland are likewise rather readily diagnosed, because of the fact that they can be similarly palpated as arising in the submaxillary gland by combining external palpation with internal palpation by means of a finger in the mouth.

Two of the tumors of the neck which will not infrequently require differentiation are *carotid body tumors* (Figs. 59 and 60) and *branchial cysts* (Figs. 61 and 62). They are frequently located at about the same level. Branchial cysts are often so tensely filled with fluid that their consistency deceives one into thinking that they are tumors, and the differential diagnosis between the two types of tumors is not easy.

There are certain features of each, however, which will aid one in at least being reasonably suspicious of the diagnosis. It is to be recalled that the course

of a branchial sinus, from which a branchial cyst arises (Fig. 63), is from a point just in front of either sternomastoid upward beneath the skin, beneath the belly of the digastric muscle to enter the pharynx at the region of the tonsil. Unlike



Fig. 59. This illustration shows a carotid body tumor, with its tendency to extend beneath the angle of the jaw and to grow inward and not outward as seen in the illustration of the branchial sinus.



Fig. 60. This also is a carotid body tumor and has the same characteristics, inward growth, as shown in Figure 59.

carotid body tumors, the course of a branchial sinus is extremely superficial, directly beneath the skin, until it reaches the level at which it passes beneath the belly of the digastric muscle. It is obvious, then, that the tendency of thyroglossal cysts will be to enlarge outward, in contradistinction to that of carotid



Fig. 61. This is a photograph of a patient with a branchial cyst, showing the tendency of this type of tumor, as discussed in the text, because of its superficial location, to grow outward and downward.



Fig. 62. This also is a photograph of a patient with a branchial cyst, showing in this case that the distinguishing feature of external enlargement is not as apparent as in Figure 61, again demonstrating that, regardless of the distinguishing features of tumors of the neck, differentiation of them will often be difficult.

body tumors to enlarge inward, arising as they do, deeply in the neck, and situated as they are, at the notch made by the external and internal carotids.

Rarely do branchial cysts extend under the angle of the jaw as do carotid body tumors. Because of their superficial location, branchial cysts are movable, and whether or not they are cysts can be determined by the exploratory introduction of a small caliber needle.

Branchial cysts, as shown in Figure 64, can attain large dimensions; they are often rather disfiguring and, of course, because of their epithelial elements,



Fig. 63. This photograph of a branchial sinus injected with iodized poppy seed oil is shown to demonstrate the course of the branchial tract and its superficial location. This was a complete branchial sinus in which the injection could be done from the point of exit in front of the sternomastoid to the point of entrance into the pharynx.

possess always the danger of malignant degeneration, although the percentage of malignant conditions in branchial cysts is relatively low. Since they are superficially located, their removal is not difficult or dangerous and, with good exposure and dry fields, can be accomplished successfully with relatively little danger to any important structures except the large vessels, the hypoglossal nerve and, at times, the spinal accessory nerves.

Carotid body tumors are not common tumors. In a recent article reporting our experiences with 18 carotid body tumors, Warren and I[3] reported that we had found that only 300 carotid body tumors had been reported in the literature.

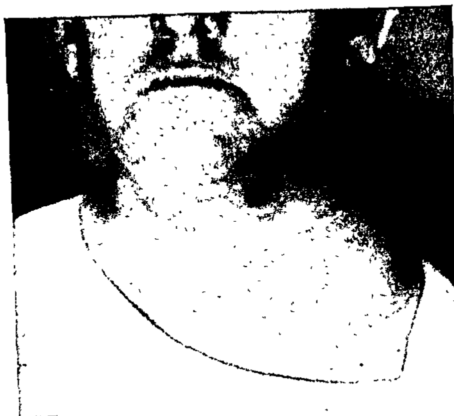


Fig. 64. This is a photograph of a large branchial cyst extending down toward the shoulder. This is of unusual size and of unusual location.



Fig. 65. This is still another photograph of a carotid body tumor, to indicate that even though the carotid body tumor may be at a location lower than the angle of the jaw, due to the fact that the carotid notch is lower, the tendency of the tumor is still to project inward and not to enlarge outward as do most of the branchial cysts.

Carotid body tumors, arising as they do from the carotid gland in the notch made by the junction of the external and the internal carotids, are as stated, deeply located tumors. Unlike branchial cysts, carotid body tumors enlarge not outward but inward and upward. They are characterized not only by their deep location but by extending upward toward the base of the skull behind the angle of the jaw, and, while, as shown in Figure 65, they do produce a swelling on the neck, the greater part of the enlargement is not outward. In the aforementioned article on carotid body tumors, attention is called to a feature of carotid body tumors which frequently may not be appreciated unless one has had some experience with them; that is, the tendency of certain carotid body tumors to bulge into the pharynx to such a degree that they can interfere with swallowing. In 2 of the patients on whom we operated for carotid body tumors, such was the



[illegible] that the tumor [illegible]

all three vessels in my actual experience has resulted ... [illegible]
opinion should never be done. It is in enveloping carotid body tumors such as shown in this illustration that removal is not advised.

intrapharyngeal bulging as the result of the pressure of *these tumors* that their removal became an urgent necessity, because of the fact that the patients were unable to swallow an adequate amount of food.

Another feature to be remembered in carotid body tumors is the fact that, unlike other tumors of the neck, they cannot be dislocated downward. Since they arise in the carotid notch, it becomes obvious that they cannot be made to move downward by pressure. Still another diagnostic point in carotid body tumors is that their deep origin just beneath the mucous membrane of the pharynx can frequently be demonstrated by bimanual palpation, with two fingers, one finger in the mouth, pressing on the side of the pharynx, and the other on the neck, beneath the angle of the jaw. One can also not infrequently determine the origin of these tumors when they are palpated bimanually by demonstrating the relationship of the tumor to the bimanually palpated common, external and internal carotid vessels.

The percentage of malignant conditions *occurring in carotid* body tumors has been placed at various levels by various authors, ranging from 20 to as high as 50 per cent. In the series of 18 cases recently reported by Warren and me there

were no malignant conditions, and since that time two additional carotid body tumors have been removed in which there were no malignant conditions.

Because carotid body tumors tend to enlarge and may ultimately require removal because of pressure, because in a definite percentage, even if they are small, malignant degeneration will occur, it is my opinion that all carotid body tumors should be excised if possible. When, however, the carotid body tumor surrounds all three vessels, as shown in Figure 66, necessitating the ligation of all three vessels for its removal, I do not believe that its removal is justifiable. In my hands, the mortality of this procedure has been 33 per cent, which I believe

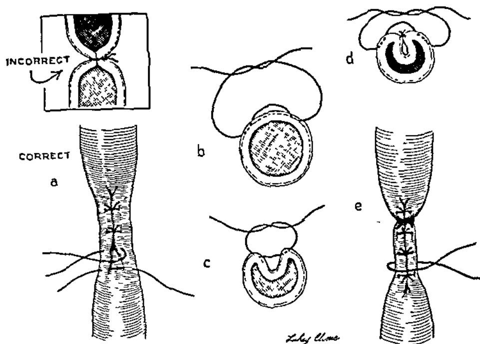


Fig. 67. In this illustration (supplied by Dr. James L. Poppen of the Neurosurgical Department of the Clinic) is
then ligature to avc
is the method that
aneurysms.

is higher than the incidence of malignant degeneration. In the cases in which ligation of all three vessels is necessary I believe that the tumor should not be removed. When, however, malignant degeneration has been demonstrated or when the size of the tumor and its pressure on the pharynx with its increased size are such as to interfere with swallowing and when, in addition, it becomes evident that the tumor can be removed only by the ligation of all three vessels, I believe that a preliminary low ligation of the common carotid by the infolding plan devised and practiced by Dr. James L. Poppen in the Neurosurgical Department of the clinic, in the management of intracranial aneurysms, is the plan to be employed (Fig. 67). With the common carotid infolded and ligated for six weeks, particularly when afterward heparinization is done to avoid thrombosis, later removal with ligation of the external and internal carotids will prove distinctly less hazardous.

What used to be called lateral aberrant thyroids supposedly arising from the ultimobranchial bodies, as shown diagrammatically in Figure 68, can be made

up of multiple nodules or a single discrete nodule as shown in Figure 69. These tumors, previously thought to be lateral aberrant thyroids, are now known to be secondary tumors to palpable or nonpalpable malignant tumors of the thyroid in the lobe on the same side. They are usually papilliferous in character and the pathologic report is usually either papillary adenocarcinoma or adenocarcinoma. It is to be remembered that when such a lateral discrete tumor or multiple tumors

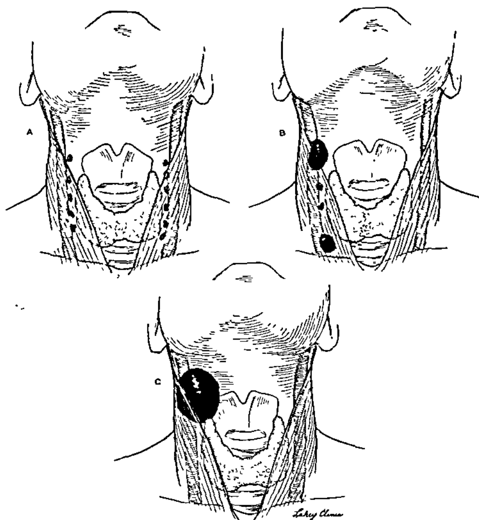


Fig. 68. In this illustration (*A*, *B* and *C*) are shown the three types of what previously were thought to be aberrant thyroids but are now, as stated in the text, known to be metastases to the nodes in the neck from a primary tumor, often not palpable, in the lobe of the thyroid on the same side. As may be seen in these three illustrations, these metastases may be multiple and small, they may be large and small, or the metastasis may be a single nodule.

are found with this pathologic report, there will in practically every instance prove to be a primary tumor in the lobe on that side. It is in these cases that radical neck dissection together with total removal of the thyroid on that side is done, to be followed by high voltage x-radiation.

Neurofibromas of the neck, as shown in Figure 70, can occur at any level and at any location on the neck and can arise from any of the nerves in the neck. In Figure 71 is shown one which occurred beside the pharynx, and in it the deviation of the esophagus filled with barium sulfate can be seen. They are discrete and firm, and the final diagnosis in these tumors can be made only with a patho-

logic report. They are of a low grade of malignancy; they tend to recur locally and should be removed radically, and one should take care that they are removed completely and intact.



Fig. 69. This is a single discrete metastatic nodule from a primary tumor, unrecognized, in the left lobe of the thyroid. In comparing this photograph with one of a patient with a branchial cyst, one can easily see how difficult it is to differentiate some of the tumors in the neck.

This is the type of metastatic thyroid which, as described in the text, is to be treated by radical dissection of the neck with the removal of the metastatic tumor and total removal of the thyroid lobe on that side, in which in practically every instance a primary tumor will be found.

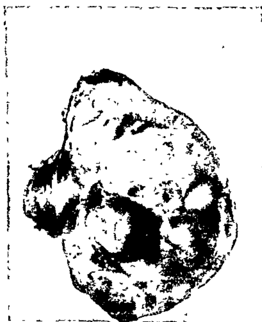


Fig 70 A neurofibroma removed from the neck in the region of the pharynx.

Three types of tumors have occurred, in my experience, of parathyroid origin—parathyroid cysts, parathyroid adenomas and discrete lateral malignant growth

of parathyroid origin. *Parathyroid cysts* have been seen up to the size of a horse chestnut and parathyroid adenomas, likewise, up to the size of the horse chestnut. Parathyroid cysts and parathyroid adenomas have occurred in direct relationship to the thyroid gland and have been seen located posterior to it. The rare malignant growths of the neck of parathyroid origin which I have seen have been of considerable size and not related to the thyroid itself. They have been discrete laterally located movable tumors of the neck, and the diagnosis has been made in every case only with the pathologic report.

Lymphosarcoma has occurred, in my experience with tumors of the neck, as a discrete tumor and as Hodgkin's disease. Discrete primary carcinoma of the



Fig. 71. In this illustration may be seen the outline of the shadow of the neurofibroma beside the pharynx, as indicated by arrows.

neck arising in the branchial tract has likewise occurred in my experience, and all of these tumors have been diagnosed solely on the basis of the pathologist's report.

Discrete tuberculous cervical nodes have occurred in my experience, but much less commonly than in the past, when this disease was particularly common in children, prior to almost routine tonsillectomy in children and prior to inspection of milk herds for tuberculosis. Tuberculous adenitis of the cervical nodes most commonly occurs in the region drained by the tonsils. The nodes most commonly involved discretely are those just below the angle of the jaw and in front, beneath or behind the sternomastoid muscle. While tuberculous cervical adenitis can occur as a discretely involved gland, it does not usually occur in a single gland. The diagnostic feature which will be helpful in one's suspicion of the diagnosis is the fact that in any tuberculous gland which has reached the size of a horse chestnut rarely will caseation be absent. In the presence of caseation rarely will calcium deposits be absent which can be demonstrated by the roentgenogram, and this suggests the diagnosis of tuberculous lymph node.

If a tuberculous node of the neck does occur as a discrete involvement of a single node or set of nodes, excision followed by radiation is a most satisfactory form of treatment. It is to be recalled, however, that the spinal accessory nerve passes beneath the sternomastoid at this point where discrete tuberculous glands of the neck are so likely to occur, that is, behind the middle portion of the sternomastoid muscle, and that, in dissection of the tuberculous node here, this nerve is in danger. It is to be recalled also that the spinal accessory nerve innervates the trapezius, which by scapular rotation provides the last 90 degrees of abduction of the arm, and that injury to it results in serious loss of motion and function of the arm.

Discrete adenomas of the thyroid should never be difficult to diagnose, since, with few exceptions, that is, those adenomas extruded from the thyroid, the discrete tumor can be palpated as arising in one of the lobes of the thyroid. There is one distinguishing characteristic of a tumor, discrete or multiple, arising in the thyroid gland, and that is the fact that it ascends and descends with swallowing. The only other tumor occurring at this location that I know of which ascends and descends with swallowing is the fibroma of the esophagus.

*Table 3. Incidence of Malignancy in Thyroid Adenomas**

Year	Total Thyroid Tumors	Malignant Conditions, Percentage
1926	443	3.6
1927	501	4.0
1928	526	10.8
1929	655	7.3
1930	574	4.3
1931	504	3.5
1932	495	3.2
1933	426	3.5
1934	495	5.0
1935	433	3.5
Total	5,052	

* Because of the statements which are being made of late that there is little danger of malignancy in adenomas of the thyroid, its incidence over a ten year period in 5,052 cases of tumor of the thyroid is recorded.

Discrete adenomas of the thyroid with their relationship to thyroid malignancy (Table 3), in my opinion, should all be removed, since the mortality in removal of these tumors should be zero.

It is to be recalled that inclusion cysts of the neck (*dermoid cysts*) can occur at any level (Figs. 72 and 73), from the back of the tongue to the level of the clavicle.

Attention has been called to the fact that *lipomas* can occur in any portion of the neck, but the possibility of this diagnosis should not be forgotten in considering any tumor of the neck not of solid consistency.

LATERAL MULTIPLE TUMORS OF NECK

The lateral multiple tumors of the neck, consisting of Hodgkin's disease, tuberculous cervical adenitis, metastatic carcinoma of the thyroid, cystic hy-

gromas of the neck and multiple colloid adenomatous goiters, present particularly difficult diagnostic problems.

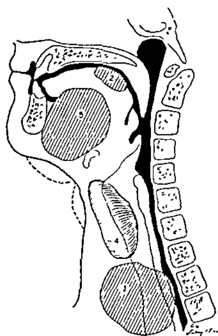


Fig. 72. This diagrammatic illustration demonstrates the levels at which inclusion cysts (dermoids) can occur, in the back of the tongue to the level of the clavicle, in order of their frequency of occurrence in my experience.

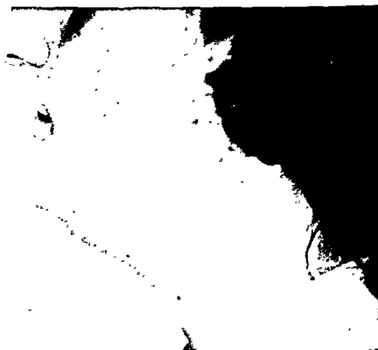


Fig. 73. A dermoid cyst in the midline beneath the jaw.

I do not believe that it is possible to distinguish, with any definite certainty, *Hodgkin's disease* from *tuberculous cervical adenitis* by any other means than biopsy. When Hodgkin's disease occurs in multiple locations, one can be suspicious of it. When the character of the glands in Hodgkin's disease is typical,

that is, multiple movable grapelike structures without inflammatory reaction, one may be suspicious of Hodgkin's disease, but the final differentiation between tuberculous nodes of the neck, lymphosarcoma and the various other tumors of the neck, either single or multiple, can be made with certainty only by the removal of a node and on the basis of the pathologic report. While multiple glands of Hodgkin's disease, when it is diffuse in character, are not usually fused together, as inflammatory glands seen with tuberculous cervical adenitis often are, I have seen tuberculous cervical adenitis occur in all forms and types and have never attempted to do more than consider the possibility of both lesions and settle the final diagnosis by biopsy.



Fig. 74. A cystic hygroma of the neck, beneath the jaw. Again, this demonstrates how difficult it is to differentiate many of the cysts or tumors of the neck. From its location, this could easily be a tumor of the submaxillary gland.

Multiple metastatic tumors from a primary malignancy in the thyroid lobe on the side in which the metastases have occurred used to be thought of and described as lateral aberrant thyroids. It is now known, as already stated, that this lateral chain of glands, often existing without fusion, without enlargement and without symptoms over a long period of time, is secondary to a primary tumor, either papillary adenocarcinoma or adenocarcinoma, in the thyroid lobe on the same side. They may occur as small, discrete, chainlike series of glandlike structures, they may contain an occasional large, discrete, glandlike mass or they may, as shown in Figure 69, represent a lateral gland invasion as a single discrete movable tumor.

Little need be said about the diagnosis of *multiple colloid adenomatous goiter*, since the diagnostic features which attach themselves to the discrete adenoma of the thyroid are likewise true of multiple adenomas of the thyroid; that is, their origin within the thyroid and the fact that they ascend and descend with swallowing. These features should in practically all cases make it possible to settle

when multiple tumors of the neck are multiple adenomatous goiters and to distinguish them from the other lesions producing multiple tumors, carcinoma of the thyroid, tuberculous cervical lymph nodes, Hodgkin's disease or multiple lymphomas.

Cystic hygromas of the neck, with their diffuse character and their cystic consistency, in most instances are not difficult to diagnose (Fig. 74).

LOW TUMORS OF NECK EXTENDING INTO MEDIASTINUM

In discussing tumors of the neck one should not fail to mention the differential diagnosis of the low-lying tumors of the neck, particularly those that either



Fig. 75. This is a photograph of an intrathoracic goiter, showing the extrathoracic and intra thoracic portions. (From New England J. Med. 236 60 [Jan. 9] 1947.)

extend into or emerge from the supraclavicular space, the commonest of which is *intrathoracic goiter.* This is the type of goiter which is largely intrathoracic, with its topmost portion projecting up through the upper thoracic strait, so that it can be palpated above the clavicle in the root of the neck. Intrathoracic goiter is the commonest of all the low-lying tumors of the neck which extend into the

mediastinum, and has several rather typical characteristics. Again, as is true of all tumors of the thyroid, it is the only tumor in the neck, exclusive of the fibromas of the esophagus, an example of which is shown in Figure 75, which ascends and descends with swallowing. Since intrathoracic goiters are oftenest discrete adenomas of the thyroid which have descended into the mediastinum with their upper surface showing above the clavicle and arising usually in a lateral lobe, they will deviate the trachea characteristically either to the right or to the left, as shown in Figure 76. They are practically the only tumor in the lower

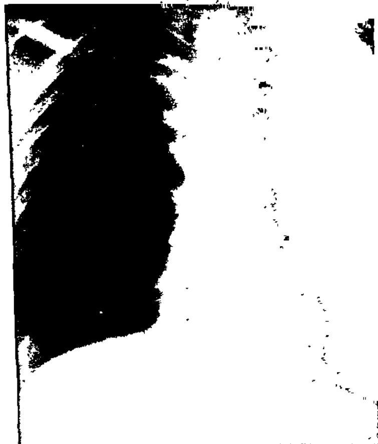


Fig. 76. This roentgenogram demonstrates the deviation of the trachea which occurs with the intrathoracic goiter shown in the previous illustration, showing the deviation of the trachea to the left or to the right, which occurs in the typical adenomatous thyroid which has descended into the mediastinum.

part of the neck which curves the trachea symmetrically, as shown in Figure 76. They have the additional feature that they are usually smooth in outline and that in a roentgenogram they will usually show a shadow with a sharply demarcated outline.

Fibroma of the esophagus, which occurred in 3 patients who were operated on for its removal, as shown in Figures 77 and 78, is the only tumor of the lower part of the neck other than intrathoracic goiter which ascends and descends with swallowing. Outside of the fact that its outline frequently can be brought out when barium sulfate is ingested, showing distortion of the esophagus, it is practically impossible to distinguish it by roentgenogram or by palpation from

an intrathoracic goiter. There is a point which becomes valuable at the time of operative exposure, by means of which it can be settled that this intrathoracic tumor, occurring on the lower portion of the neck, is an intrathoracic goiter or an intrathoracic fibroma of the esophagus, and that is the relationship of the recurrent laryngeal nerve and the inferior thyroid artery to the tumor. As the neck is opened and the tumor exposed, if the inferior thyroid artery and the



Fig. 77. This roentgenogram demonstrates a fibroma of the esophagus as brought out by barium sulfate in the esophagus, showing the intrathoracic location and how readily it can, on palpation, simulate an intrathoracic goiter, particularly when one remembers that it ascends and descends with swallowing.

recurrent laryngeal nerve run over the anterior surface of the intrathoracic tumor, it will be a tumor of esophageal origin and not of thyroid origin, for if the tumor be of thyroid origin the inferior thyroid artery and the recurrent laryngeal nerve, because of their developmental origin and anatomic course, will be behind the tumor. In all 3 cases of fibroma of the esophagus, the tumors were successfully removed without opening the esophagus and contaminating the mediastinum.

There occasionally arise *secondary malignant growths* in any location in the neck, such as discrete tumors of Virchow's gland behind the insertion of the left sternomastoid process. This has been such a classic lesion that one should never fail to remember it and to search for it in any examinations of the neck for

tumors. Failure to find Virchow's glands and thus demonstrate them as secondary to carcinoma of the stomach has occurred unfortunately more than once in everyone's experience and has resulted in an unnecessary exploration to determine the operability in carcinoma of the stomach when, had the gland been discovered, inoperability could have been determined and exploratory operation avoided. Virchow's glands occur as single discrete movable tumors or can have extended until they are represented by a firm fixed mass behind the insertion of the sternomastoid, with a broad fixed base and a firm apex pointing upward. At this stage, secondary extension in the region about the thoracic duct has taken place, and these can rarely be missed.



Fig. 78. Specimen of the fibroma of the esophagus removed through the neck.

Another type of secondary malignant growth, secondary to carcinoma particularly in the upper lobe of the lung, will occasionally be observed extending above the clavicle. It is a fixed firm mass, unfortunately at times the first evidence of the presence of such a bronchiogenic carcinoma.

In discussing the diagnosis of tumors of the neck, I am aware of the fact that even after extensive experience with such tumors such discussions seem inadequate and that one can do no more than mention some of the features of these tumors which will make one suspicious of what the diagnosis may prove to be if the tumor is removed and the pathologic report received. So uncertain do I feel, both as to diagnosis and the possibility of malignancy, that in practically all patients with tumors of the neck who come to me for opinion, one of two things is usually done: A gland is removed for pathologic report, or the tumor is explored with the purpose of removing it.

SUMMARY

The importance of immediate removal of tumors of the neck and a pathologic report, because of the danger of malignancy, is stressed.

The various types of tumors of the neck, median, single, lateral, single and multiple, are listed and certain of their features discussed.

The uncertainties in determining the exact nature of all tumors of the neck, exclusive of thyroglossal cysts, adenomas of the thyroid, the neck dermoid and the cystic hygromas, are stressed, and the need for early exploration with the purpose of removal or an early biopsy in multiple tumors is strongly urged.

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A LONG TERM APPRAISAL OF CAROTID BODY TUMORS WITH REMARKS ON THEIR REMOVAL

FRANK H. LAHEY AND KENNETH W. WARREN

The limited number of tumors of the carotid body reported indicates that it is not a common tumor of the neck, yet the fact that we have had 22 of these tumors to deal with proves that they are by no means rare. They are a serious type of tumor in terms of their capacity to make trouble and are particularly serious in reference to the proper selection of their method of management.

In an effort to help us and aid others in formulating a rational plan of management in patients with these tumors, we have discussed, in a previous communication,[14] certain factors relative to the clinical and pathologic nature of these tumors, as well as the risks of surgical removal. In this communication we also discussed the effectiveness of alternative therapy (roentgen irradiation). We analyzed 18 cases of carotid body tumors taken from the records of this clinic and on the basis of the cumulative literature and our own clinical experience with these tumors emphasized that they exhibit two distinctly undesirable characteristics. They become malignant in only a small percentage of cases. They at times entirely surround and include the common, external, and internal carotid arteries and become so fused with these structures that they can be removed only by ligating these vessels, a procedure which is associated with a prohibitively high morbidity and mortality. We concluded in this communication that if the carotid body tumor is found to surround the internal, external, and common carotid arteriès completely so that excision of the tumor would necessitate the ligation of these vessels, removal should be done only when biopsy reveals a malignant tumor. Strict adherence to this plan of decision in these types of cases on our part appears to have eliminated some of the tragic consequences of the surgical excision of carotid body tumors. With these experiences in mind it is obvious that it is extremely important for everyone who has had any considerable experience with cases of this type to record particularly the percentage of malignant tumors occurring in their series of carotid body tumors and also the percentage of cases in which the tumor includes the three great vessels, and to record in the appraisal what has happened to the patients in whom it did not seem wise to remove the tumor.

It is with these points in mind that we wish to review our total experience with these tumors and to record the long term results.

ANATOMY

The carotid bodies, first described by von Haller in 1743, are two in number, situated near the bifurcation of each common carotid artery. They are oval, gray

Originally published in Surgery, Gynecology and Obstetrics, 92:481–491 (April) 1951.

or reddish brown, and measure about 5 millimeters in their greatest diameter. The structure is surrounded by a fibrous capsule from which projections penetrate the substance of the gland, dividing it into lesser lobes and lobules.

Microscopically, the gland is distinctly lobular. The characteristic cells are usually arranged in whorls or alveoli which are surrounded by a supporting stroma containing many capillaries (Kohn).[11-13] This essential structural pattern is brought out clearly by silver impregnation of the reticulum. The individual cells are polygonal with finely granular protoplasm and a large oval nucleus rich in chromatin.

Kohn has emphasized the affinity of certain cells of the carotid bodies for chromium salts and has concluded that the chromaffin reaction indicated an origin of these cells from the sympathetic nervous system. DeCastro[4, 5] was unable to substantiate this chromaffin reaction. LeCompte,[15, 16] in studying several of these tumors including some from our series, could not demonstrate a true chromaffin reaction.

EMBRYOLOGY

Kohn's original concept that the essential cells of the carotid bodies were derived from the sympathetic nervous system has been challenged in recent years by several investigators. Smith has thought that mesodermal elements combined with components from the glossopharyngeal, vagus, and sympathetic nerves. Boyd has held a similar view and has emphasized the point that the mesenchymal elements from the region of the artery of the third branchial arch are the most important anlagen in the derivation of the carotid body.

FUNCTION

The apparent affinity of the cells of the carotid body for chromium salts led the early investigators to speculate regarding the ability of these cells to elaborate epinephrine. Recent investigators, including Christie and LeCompte, have concluded that they do not produce epinephrine, although LeCompte demonstrated the presence of a pressor substance, apparently not epinephrine, in one of the tumors included in this series. DeCastro's suggestion that the carotid bodies are chemoreceptors has been supported by the investigations of Heymans and Bouckaert, of Schmidt and Comroe, and of Dripps and Comroe.

The first carotid body tumor was removed by Riegner in 1880 and described by Marchand in 1891. The carotid artery, the jugular vein, the vagus, hypoglossal, and sympathetic nerves were divided. The patient died on the third postoperative day. In 1866 Maydl and Gersuny each excised a carotid body tumor, with recovery of the patient. The common, external, and internal carotid arteries were divided in each instance with resulting hemiplegia in the case reported by Maydl. Albert, in 1889, excised the first carotid body tumor without sacrifice of major vessels, but the tumor recurred within one year. Collective reviews by Keen and Funke (1906), Reid (1920), Royster (1924), Phelps, Case, and Snyder (1937), Bevan and McCarthy (1929), and Gratiot (1943) have helped to clarify the many problems relating to the diagnosis and treatment of this disease.

PATHOLOGY

The pathology of the carotid body is limited to tumor formation. These tumors have been designated adenomas, peritheliomas, endotheliomas, hamartomas, paragangliomas, neuroblastomas, and more simply, carotid body tumors. With such lack of unanimity regarding nomenclature it seems preferable to employ the latter term.

Grossly, the tumors tend to retain the shape, lobulation, and encapsulation of the normal carotid body. They are firm, compressible, slow growing tumors which at times, as stated, eventually encircle the carotid vessels on the affected side. They vary considerably in size, with the largest tumor, reported by Reid, weighing 190 grams.

LeCompte,[15] in 1948, analyzed 17 carotid body tumors, 15 of which were from the series reported by us in 1947. He noted the wide variation in microscopic patterns previously recorded in the literature. In view of the lack of any uniformity in microscopic arrangement he suggested that these tumors be designated by the noncommittal term "carotid body tumor."

Although the weight of the tumors in this group was not recorded in most instances, three weighed 28, 50, and 60 grams, respectively. Most of the tumors were well encapsulated, but those in which a segment of the carotid artery was resected were densely adherent to the vessel wall. Grossly, the tumors were firm and homogenous.

Microscopically, LeCompte divided the tumors into three groups. The most common type is the variety in which there is a fairly faithful reproduction of the normal structure. The second was designated the adenoma-like type and was characterized by a cellular arrangement in which the chief cells had a pronounced epithelial appearance. The cells were round or polyhedral, contained abundant cytoplasm, and were grouped in sheets or rows. The supporting stroma was minimal in this variety. The third type was called the angioma-like pattern. The cells were more compressed, spindle-shaped or crescentic and closely apposed to a rich capillary network. These various patterns were frequently present in the same tumor so that, despite these variations, the essential histologic picture was reasonably uniform.

THE INCIDENCE OF MALIGNANCY

Malignant manifestations, such as variation in size and shape of the individual cells, mitoses, and invasion of the capsule and adjacent structures, are said to occur in 15 to 20 per cent of cases (Gratiot). Harrington, Clagett, and Dockerty have expressed the view that 50 per cent of the tumors in their series showed definite microscopic evidence of malignant change. They suggested that "it might be well to regard these neoplasms as being low grade malignant lesions possessing potential powers of, if not actual tendencies toward, invasion and metastases." LeCompte, on the basis of his microscopic analysis of 17 carotid body tumors (including 15 from our original series), disagreed quite positively with this suggestion. He found no microscopic evidence of malignant disease in this group. He observed considerable variation in nuclear size, but pointed out that similar nuclear changes are seen in other benign tumors such as parathyroid adenomas. Mitoses were rarely seen. Willis stated "with few and doubtful excep-

tions, tumors of the carotid body are benign, growing slowly, remaining sharply circumscribed and producing no metastases."

Metastases to regional lymph nodes have been alleged to occur. LeCompte, in an extensive review of the literature, found only 2 cases of histologically proved metastases in lymph nodes. In one of these he thought that the nodal involvement may have been due to direct extension. In this group of our 22 patients now reported with carotid body tumors, there was no conclusive evidence of malignant growth in any instance. In 1 patient with a histologically benign carotid body tumor there was a separate glomus jugularis tumor on the same side which invaded the mastoid process of the temporal bone, and although it appeared benign cytologically, it must be considered as locally malignant. In another tumor arising from the glomus jugularis with a microscopic picture identical with carotid body tumor, there were definite metastases to one of five cervical lymph nodes. One patient, whose tumor had been present for nine years when first observed at this clinic, had at that time a simple biopsy of the growth on March 25, 1939. It was considered a benign carotid body tumor on histologic grounds. Chest roentgenograms, however, revealed 3 parenchymal lesions which were thought to be metastatic growths. Since the patient is still living ten years later and doing her own housework, and there has been no increase in the size of the cervical tumor, it must be assumed that the interpretation of this chest roentgenogram was incorrect and that the tumor was benign. For purposes of establishing the risk of malignant disease in carotid body tumor it can be said that in the true carotid body tumors in this series there has been no proved instance of malignancy. Both of the tumors in this series arising from the glomus jugularis, which because of their identical histologic character and because they can, on the basis of anatomical proximity, be confused with carotid body tumors, have been included as a subgroup in this series. There was evidence of local invasion in one of these cases and metastases to 1 of 5 cervical nodes in the other. We have reported these 2 cases in this series for the benefit of others who may have to deal with similar cases. Because they are not true carotid body tumors as clinically classed we do not think they should be allowed to affect the percentage figure of the incidence of malignancy in this group of true carotid body tumors.

It seems reasonable to conclude that the incidence of malignant manifestations in carotid body tumors is very much lower than has generally been assumed and reported. The concept that these tumors are frequently malignant has been largely responsible for the persistence with which their surgical excision has been so generally pursued, often even when their removal has required ligation of the carotid arteries on the involved side. This observation is made with no purpose of undue criticism, particularly as we have been guilty of this attitude ourselves in the past before we had had sufficient experience with these tumors to take a position based upon personal experience. This critical comment is made and this report submitted in an attempt to demonstrate that the fear we have had in the past of the danger of malignancy in carotid body tumors has, at least from our experience, been an unfounded one.

CLINICAL FEATURES

Tumors of the carotid body are generally unilateral, but may occasionally be bilateral. They are slow growing, essentially asymptomatic lesions, situated deeply

beneath the sternomastoid muscle at the level of the bifurcation of the common carotid artery. Because they are attached to the carotid vessels at the carotid notch these tumors are mobile in the horizontal, but not in the vertical plane. They are firm, compressible growths, which occasionally exhibit a bruit. They are sometimes associated with vague pains and occasionally one will attain such size and so enlarge or project inward into the pharynx as to cause real interference with swallowing. We have reported 2 such cases in a previous paper[14] on this subject. Spontaneous injuries of cranial nerves are rare. Two cases of such nerve involvement were also reported previously.

Most carotid body tumors cause no subjective symptoms. Growth in these tumors is so gradual and subjective manifestations are so mild or absent that patients usually delay in seeking medical advice until the tumors have attained quite considerable size. The duration of symptoms in our cases, when they occurred, varied from three months to sixteen years. In the average recorded series the mean duration of symptoms prior to surgery was six years. In this group of 23* cases, 22 patients sought advice because of a swelling in the neck, while only 1 patient was unaware of the cervical tumor, it being discovered during a routine physical examination. Seven patients had mild pain in the face or neck, 3 experienced hoarseness, and 1 complained of dysphagia. Three patients had bilateral carotid body tumors. Three siblings in one family were included in this series and there were 2 other members of the family who were treated elsewhere for carotid body tumors. A thrill and bruit were recorded in 3 cases. Involvement of cranial nerves was present in 2 patients, the hypoglossal nerve being affected in one instance and the recurrent laryngeal nerve in another. In 2 patients the tumor projected into the pharynx. Both of these were successfully removed. In one of these the intrapharyngeal enlargement and projection was of sufficient amount to interfere with swallowing and nutrition. This patient, an Army officer, had had two attempts at removal of the tumor in the Army, one by an external approach and one by a transoral approach. Both were unsuccessful and he came to the clinic for further attempt at surgical removal and because of his increasing inability to eat. The tumor, which had extended to the base of the skull, was successfully removed by the combined external and intrapharyngeal routes.

DIFFERENTIAL DIAGNOSIS

The 4 laterally located, single and movable tumors of the neck, as stated in a previous paper,[14] were branchial cysts, carotid body tumors, solitary lateral aberrant thyroid masses and neurofibromas.

The lesion most commonly confused with carotid body tumor is branchial cyst. These cysts, forming as they so frequently do in the lower half of the tract, are so superficial in character and located, as a rule, well below the level of the bifurcation of the carotid artery, that they tend to become more and more superficial and to bulge more and more outward as they enlarge (Fig. 79).

In contradistinction to this, carotid body tumors, located as they are in the carotid notch, originate at a higher level and are more deeply located (Fig. 80). As they enlarge, they project upward under the angle of the jaw, sometimes to

* This includes a glomus jugularis tumor without a true carotid body tumor. Note there is also included another glomus jugularis tumor in which there were also bilateral true carotid body tumors.

the extent that they become adherent to the base of the skull, and at times extend inward until, as we have seen in 2 of our cases, they bulge into the pharynx and, as happened in 1 of our cases, seriously interfere with swallowing.

Single lateral aberrant thyroid masses or solitary cervical metastases from a malignant thyroid tumor constitute the other common discrete cervical growth which we have confused with a carotid body tumor. When these tumors are multiple, as they so frequently are, they will not need to be differentiated from tumors of the carotid body. When they occur, however, as a single discrete, laterally located, movable tumor mass, as they occasionally have in our experience, they can and have been confused with a carotid body tumor.



Fig. 79. Branchial cyst.



Fig. 80. Carotid body tumor.

These lateral tumors of thyroid origin are frequently deep in location, discrete in character, and differ from carotid body tumors only in that they do not tend to enlarge upward under the jaw and, unlike carotid body tumors, can be moved upward and downward.

Neurofibromas may occur at any conceivable location, and when they appear in the region of the bifurcation of the carotid artery and are discrete and mobile, they are almost indistinguishable from carotid body tumors.

TREATMENT

It is important to diagnose carotid body tumors correctly before operation, if possible, in order that one may have in mind the possible mortality hazard of ligating the common and internal carotid arteries, which may prove necessary if the decision to remove the tumor is made and in order that one may have his mind made up preoperatively as to what he will do should removal be possible only by ligation of the carotid arteries. It is important to explain before operation to the patients and their families that such may be the character and location of the tumor that the danger of its removal may prove too great to accept. This will serve to avoid misunderstanding and unhappiness on the part of the patient and the family.

Preliminary carotid compression, graduated over a period of seven to eight days, from one minute three times a day to ten minutes three times a day, may occasionally give valuable information as to which patient will not tolerate ligation of the common or internal carotid arteries. Ability to tolerate carotid compression for ten minutes three times a day does not give dependable assurance, however, that the common and internal carotid arteries can be interrupted safely

at the time of operation if the necessity arises, and we would advise against accepting this as evidence that all three vessels can be ligated. Nor has it been proved that compression of the carotid artery for increasing time periods necessarily increases the collateral circulation to the brain. In spite of the fact that compression of the common carotid artery could be tolerated without symptoms, fatalities occurred in 3 out of 7 patients with carotid body tumors in whom ligation of the common, internal, and external carotid arteries was necessary to remove the tumors completely. A catastrophe may be expected in a high percentage of cases in which ligation of these vessels is performed.

TYPES OF OPERATION PERFORMED

The tumor was completely excised in 11 of our cases without ligating the carotid arteries. There was 1 death from cerebral damage in this group. Autopsy revealed that although the carotid body tumor had been successfully removed without ligation or division of the carotid arteries, complete thrombosis of the internal carotid artery had occurred and caused death. Autopsy demonstrated that carotid thrombosis was brought about in this patient by a sclerotic plaque being broken off during the manipulation of the carotid incidental to the removal of the carotid body tumor, the plaque projecting into the intima. One must have this possibility in mind in any patient with sclerotic carotids even though the tumor is always readily removable without ligating the vessels. In 1 patient subtotal removal of the tumor was accomplished without ligation of the major vessels. It was necessary to ligate the internal, external, and common carotid arteries at the time of operation in 6 instances. There were 3 deaths in the group, all from cerebral complications. Two of the 3 survivors had major cerebral manifestations which gradually cleared. In 2 other patients the common carotid artery was ligated, in 1 as a preliminary operation preparatory for subsequent removal of a glomus jugularis, and in 1 a ligation had been done as an emergency maneuver to control hemorrhage during an unsuccessful attempted removal of a carotid body tumor in another institution. Both of these patients withstood the ligation well, although 1 of them, an elderly hypertensive woman with the glomus jugularis, died of a cerebral accident fourteen months after the operation. In 2 cases simple biopsy of the tumor was made, and in 1 case, in which a biopsy had been done elsewhere nine years prior to examination at the clinic, re-exploration was declined. The original biopsy specimen showed no evidence of malignant disease, and the tumor had not enlarged in the ensuing nine years.

In addition to the 2 patients who had temporary hemiplegia following removal of a carotid body tumor, 4 patients had paralysis of the hypoglossal nerve, 1 had paralysis of the recurrent laryngeal nerve, and 1 patient, in whom a carotid body tumor and a glomus jugularis were removed at separate operations, had paralysis of the seventh, tenth, eleventh, and twelfth intracranial nerves following the very radical intracranial procedure required to remove the glomus jugularis.

There were 4 deaths in the group of 23 patients who were observed for carotid body tumors, a mortality of 17.4 per cent. These 4 deaths occurred in the group of 20 patients in whom the carotid body tumor had been excised, giving a mortality for resection of 20 per cent. The mortality for excision of the carotid body tumor accompanied by immediate ligation of the common, internal, and external

carotid arteries was 50 per cent. Since the common carotid artery was ligated in 2 patients as a preliminary maneuver to subsequent excision of 1 carotid body tumor and 1 glomus jugularis respectively without a fatality, there was a total of 8 patients who had ligation of the common carotid artery with 3 deaths, a mortality of 37.5 per cent.

It should be recorded for the benefit of others and for the purpose of establishing our conclusion, that all these fatalities occurred in patients with lesions which were proved benign on pathologic examination.

SUBSEQUENT COURSE

The 3 patients who survived excision of a carotid body tumor and ligation of the common, internal, and external carotid arteries are all living and well, 2 of them five years and one six years after operation. The 2 who had temporary paraplegia have recovered completely. The patient whose common carotid artery was ligated to control hemorrhage at exploration of the tumor in another hospital and who subsequently had the carotid body tumor removed and the common carotid artery divided at the clinic, is alive and well two years following the operation, but has some impairment of her speech.

Of the 11 patients who survived excision of the tumor without ligation of the common or internal carotid arteries, 1 died five months after operation from generalized abdominal carcinomatosis. Exploration and biopsy had revealed adenocarcinoma suggesting gastrointestinal origin. There was no recurrence of the carotid tumor. The 10 remaining patients are living and well, 5 having survived a period of one to four years, and 5, from five to fifteen years.

Three patients who had simple biopsy of the tumor were alive ten, eleven, and seventeen years, respectively, following this operation.

Of the 2 patients with tumors of the glomus jugularis*, 1 died fourteen months later after being bedridden three months following a cerebrovascular accident. She was an elderly woman with long standing arterial hypertension who showed no evidence of local recurrence of the cervical tumor, despite the fact that there was metastasis to 1 of 5 lymph nodes removed at the time of operation. The other patient with a tumor of the glomus jugularis which had invaded the mastoid process, and who also had previously had a separate benign carotid body tumor removed from the same side, in this clinic, is living and well three months following the operation for the glomus jugularis.

It is apparent at least from this series and from quoted reports that the mortality following removal of carotid body tumors, when it is necessary to ligate the common and internal carotid arteries, is forbiddingly high and cannot be justified in light of the tendency of these tumors to grow slowly, to produce minimal symptoms in most instances and, in most cases, to remain benign.

Tumors of the carotid body, unless they are shown by biopsy to be malignant, unless they are enlarging intrapharyngeally so that they are progressively interfering with swallowing or causing pain, should not be excised when they surround the internal, external, and common carotid arteries completely so that their excision would require the ligation of these structures.

* These are included as a matter of record because of the rareness of these tumors.

TECHNICAL CONSIDERATIONS OF THE OPERATION

Such can be the technical difficulties of removing carotid body tumors that we have been much more concerned with wide exposure and anatomic relationships than with cosmetic appearance of the scar. For this reason we have employed long longitudinal incisions placed just in front of the sternomastoid

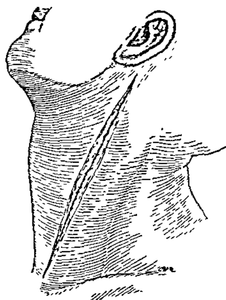


Fig. 81. This illustration is presented merely to show the location of the incision and to emphasize the need for its length.

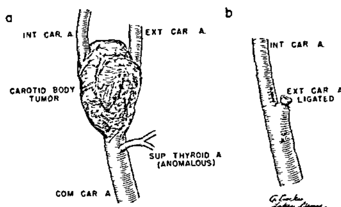


Fig. 82. The type of carotid body tumor which includes all three branches, the common, the external, and the internal carotid, is illustrated. It is in this type of tumor that removal is often impossible and in which ligation of all three vessels to accomplish such a removal is unjustifiable because of the mortality. Note that this tumor was removed by ligating only the external carotid artery, then by removing the tumor together with the adventitia of the vessel. Note also the anomalous superior thyroid artery. (From Postgraduate Medicine 5: 137–138, 1949.)

muscle. These incisions are made long enough so that the entire carotid system can be exposed and mobilized, an important step in exposing the carotid body tumor ensconced as it is in the carotid notch (Fig. 81).

After the sternomastoid has been freed and retracted laterally together with the internal jugular vein, the common carotid artery has been identified, com-

pletely isolated from the internal jugular vein and vagus nerve throughout its entire extent, the dissection of the artery is carried well down in the neck to the clavicle and up to and beyond the point of division of the common carotid into the external and internal carotid arteries. At this point the tumor comes into view together with the external and internal carotid arteries and one is able to settle whether the tumor is or is not the type which includes the common carotid artery and its external and internal carotid branches (Fig. 82). This complete dissection and mobilization of the entire carotid system (common, external, and internal carotid arteries) can be of great aid in removing some tumors of the

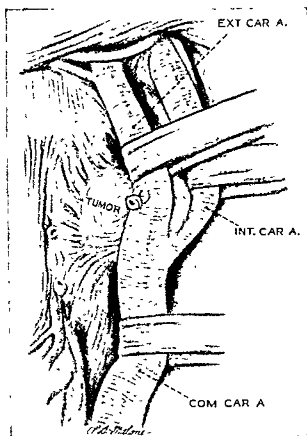


Fig. 83. Note in this illustration the complete exposure of the common carotid down to the clavicle and the external and internal carotid up to the angle of the jaw in order to obtain mobility of these structures and the included tumor. Note by lateral traction of the Penrose drain placed around the vessels, the ability to obtain an exposure which permits dissection of the carotid body tumor from the lateral pharyngeal wall. Note also the hypoglossal nerve. In many instances the tumor will be of such size that the upper two tractors placed beneath the hypoglossal nerve will serve to protect it by holding it up out of the way.

carotid body. When the internal jugular vein and vagus nerve have been completely freed from the carotids and the carotids have been completely mobilized from their lowest to their highest point in the neck, it is possible by means of the Penrose drain tractors placed around them to elevate the carotids out of their bed in the neck, together with the tumor, in such a manner that much more exposure and approachability to the tumor in the carotid notch (Fig. 83) can be obtained. If the tumor is not the inclusive type, one may also be able to determine how movable it is and how intimately it is fused into the carotid notch and to the external and internal carotid vessels.

When the tumor is small and readily movable in the carotid notch, no difficulty is encountered in its removal; when the tumor is large in most instances it is quite firmly fixed in the carotid notch and quite intimately fused with the external and internal carotid vessels. In many of these cases such is the intimacy of this fusion that one's first impression can easily be that it will not be possible to get the tumor off the carotids without rupturing these vessels, necessitating ligation, the step so desirable to avoid. It has been possible for us in several of such cases to remove the carotid body tumor successfully by taking the adventitia

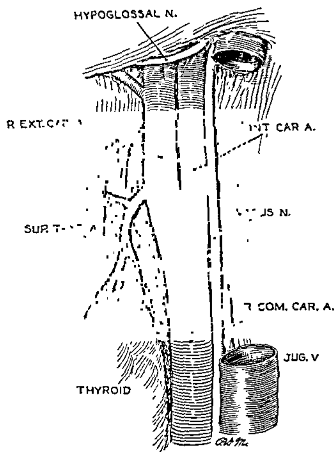


Fig. 84. Note in this diagrammatic illustration of a normal carotid structure without a carotid body tumor how narrow the carotid notch is. This illustration is presented to demonstrate, as shown in Figure 85, how these structures can be spread to bring about exposure of a carotid body tumor.

of the vessel with the tumor. This procedure is not too difficult or dangerous, particularly for anyone who has had experience with decorticating the carotids. We have been particularly aided in the removal of such nonencircling carotid body tumors by the use of the Berens magnifying loupe.

When the tumor is small enough and the neck long enough so that the external and internal carotids can be exposed and visualized well above the tumor, we have been aided in exposing these tumors by placing a loop of small Penrose tubing around each branch of the carotid (external and internal) above the tumor and a separate one around the common carotid below the tumor (Fig. 84). This maneuver provides two aids. One can, by opposed traction upon the Penrose loop about the external and internal carotids, so spread them that the nar-

row angle which they make as they form the carotid notch is so widened (Fig. 85) that exposure and separation of the tissue from either the external or internal carotid artery can more readily be started at the top of the tumor where it is attached either to the external or to the internal carotid artery. Once a line of separation between the upper part of the tumor and the external or the internal carotid is established for a short distance, one can by widening the distance between the external and internal carotids continue the separation to the notch and then start the separation at the top point of attachment of the tumor to the opposite vessel, carrying the separation downward until the tumor is attached

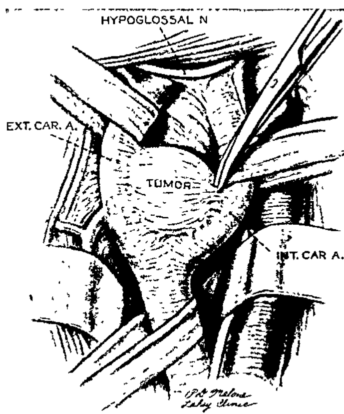


Fig. 85. In this semidiagrammatic illustration is shown the ability to spread the external and internal carotid vessels by means of the Penrose tubing tractors and the beginning of the separation of the carotid body tumor with the external and internal carotid vessels spread widely apart. Note how these tractors tend to protect the hypoglossal nerve when the carotid body tumor is large and the dissection must be made close to the hypoglossal nerve as it crosses in front of both the carotid vessels.

only at the carotid notch, at which point, with its now established mobility, it can be removed without difficulty. In some instances it will be possible to carry the dissection from the top of the tumor down to the notch and on up its attachment to the other carotid until it is completely separated.

We wish again to direct attention to the fatality, which we have reported earlier in this paper, in a patient on whom a carotid body tumor was successfully removed without ligating the carotid but in whom a plaque of sclerotic intima was so cracked in these manipulations that it projected into the vessel lumen, caused a thrombosis, and brought about a fatality. With the plan of exposure here described, one can readily realize that the decision for or against attempting removal of the tumor should concern itself seriously with the degree of sclerosis

in the vessel wall and the danger of bringing about this complication. If the vessels are soft and flexible there will be no danger in employing the method of exposure by Penrose drain traction as described.

These Penrose drain tractors have still further advantages in that external traction on all three tractors with a low dissection of the common carotid down to the clavicle permits such mobilization of the vessels together with the tumor from its position against the lateral pharyngeal wall that it can be freed from any deep position in the neck and more readily detached from its surrounding tissues, particularly the lateral pharyngeal wall. Still another value of this procedure is shown in Figures 83 and 85. The rubber drain tractors can be so placed on the external and internal carotid arteries below the point where the hypoglossal nerve crosses these two structures that the nerve is held safely up out of the way above the tractors as the dissection is carried out.

Since our experience with carotid body tumors which have enlarged inward so that they encroach upon the pharyngeal wall and interfere with swallowing and also become firmly attached to the base of the skull has been limited to but 2 cases, we can hardly speak with any degree of authenticity concerning the removal of carotid body tumors of this type. We feel sure, however, that these cases are unusual and rare in everyone's experience. They are, nevertheless, of urgent importance since they may seriously interfere with swallowing. It was fortunate in both these cases that with the inward direction of expansion of the tumor the problem of separation of the tumor from the external and internal carotids was not a great one. The two greatest problems in the removal of these two carotid body tumors were: (1) the separation of the deep tumors from the lateral pharyngeal wall because of the difficulty of obtaining exposure in this deep position with the great vessels intact (Fig. 83) and (2) the necessity of severing the final attachment of the tumor to the base of the skull by bluntly severing with the scissors passed downward on the palpating finger.

The location of the sympathetic chain directly beneath the carotid vessels and the location of the superior cervical sympathetic ganglion beneath the carotids on the upper part of the neck make avoidance of injury to this structure and the production of a Horner's syndrome difficult, particularly when the carotid body tumor is large and when it is the type which has enlarged upward under the jaw and inward into the pharynx. It is possible in the small carotid body tumors, particularly with the carotid system mobilized with the rubber tractors as shown in Figure 85, to demonstrate the sympathetic system at a level lower than the tumor and to follow it up as the tumor is dissected free and preserve it. In the very large and deep tumors such will be the difficulties of exposure of the deeper portions that blunt separation of the tumor from the pharyngeal wall with the finger will be necessary. Unless previous operations have been performed on the tumor, as was the case in our largest tumor, the separation of the tumor from the lateral pharyngeal wall with the finger has not been difficult and in both of these cases the absence of a Horner's syndrome indicates that the sympathetic chain escaped injury.

The location of the hypoglossal nerve, crossing the carotids just above the notch is such that this nerve will be in danger of injury, particularly when the carotid body tumor is large. One of the first steps in the removal of a carotid

body tumor should be the exposure of the hypoglossal nerve and settling the danger to it in the removal of the tumor. Should it be decided that the nerve might be injured during removal of the tumor, the nerve should be severed and long identifying sutures left on either end to simplify re-suture after the tumor has been taken out.

ROENTGEN TREATMENT

Since it is evident from statements already made in this paper that there will be an occasional case of carotid body tumor in which, although the tumor is not malignant, it will be unwise to advise removal because of the involvement of all branches of the carotid arteries, the question of irradiation treatment of such a tumor is bound to arise.

We have had such an experience with 3 patients all of whom have been submitted to irradiation treatment. In 2 of these patients the carotid body tumor has not increased in size, and although it has not disappeared it has been thought by all of us to have decreased moderately in size. In the third patient in spite of irradiation there was such an increase in size and inward enlargement of the tumor that it interfered with swallowing and brought about considerable discomfort. This patient has now been submitted to 2 million volt irradiation treatment, the tumor is again smaller and the patient is more comfortable. What the outlook will be with 2 million volt irradiation as compared with our experiences to date can only be answered at some later time when more of these patients have been submitted to this method of treatment.

SUMMARY AND CONCLUSIONS

Carotid body tumors are relatively uncommon. They are serious tumors in terms of the difficulty in their clinical recognition and in reference to the selection of a proper method of treatment. They occasionally entirely surround and include the carotid arteries and become so fused with these structures that the tumor can only be removed by division of these vessels, a procedure which is associated with a prohibitive morbidity and mortality.

These tumors are, for the most part, benign, slowly growing, and relatively asymptomatic.

With our experience in mind it is difficult to justify an aggressive attitude toward indiscriminate surgical removal of carotid body tumors, particularly in those instances in which they can only be excised by the interruption of the carotid vessels.

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TRENDS IN SURGERY FOR CARCINOMA OF THE LARYNX

WALTER B. HOOVER

Untreated carcinoma of the larynx is a progressive disease which produces much suffering and finally destroys the life of the afflicted, usually in one to two years. The effectiveness of therapy for malignant disease of the larynx is measured by the length of time the patient survives. To date, no hormone or selective cancerocidal substance has been discovered with curative effect upon carcinoma of the larynx. Cure of carcinoma of the larynx depends upon its complete removal or destruction.

Surgery has proved the most effective and trustworthy means available to date and treatment by radiation the second most effective method. In some instances a combination of these two factors may be used.

New technics with more extensive surgery are now possible by the use of antibiotics. Medical preparation and establishment of electrolyte balance with feeding and transfusions render the patients better risks and improved technics in analgesia and anesthesia make surgical intervention possible in cases previously considered hopeless.

In *Diseases and Injuries of the Larynx*, published in 1942, Jackson and Jackson stated: "The wide field operation is necessary if a search is to be made for nodes. Our opinion is that if there are nodes, the case is one for irradiation, not laryngectomy. Due to ligation of vessels, poor blood supply, primary union is rare." This statement is now obsolete for today, with the antibiotics, the control of the electrolytes and with transfusions, primary healing can be expected following the so-called wide field operative procedure with extensive neck dissection in which the entire neck is opened by large flaps.

Likewise, new methods of radiation therapy have been evolved and with improvement in the quality of radiation administered, the results of radiation therapy will be progressively improved.

Early diagnosis remains the most important factor in the successful therapy of laryngeal cancer. Hoarseness is the most common early symptom of intrinsic laryngeal cancer since a very small growth on the vocal cord interferes with the vibration of the vocal cord, producing hoarseness. It cannot be stressed too often that hoarseness which lasts more than three weeks should be carefully investigated by a competent laryngologist. Other early symptoms are tickling, a desire to clear the throat or to swallow, and a feeling of a lump or of something abnormal in the throat.

In any patient with these early symptoms, the laryngoscopic examination must include a view of the entire larynx, even if it is necessary to pull the epiglottis forward after cocainization of the larynx, or to do direct laryngoscopy to visualize all the structures of the larynx.

Any lesion in the larynx observed by such an examination must be considered

of malignant nature until proved otherwise by adequate or complete study of the patient which includes removal of sufficient tissue for microscopic study of the involved area in the larynx. In fact, all tissues removed from the larynx should be sectioned and studied by a competent pathologist. In most instances it is not difficult to make a diagnosis by such methods. It is only in an occasional case that the well-trained laryngologist may be confused. The exact size and extent of the lesion may be difficult to ascertain, however, and it may be necessary to open the larynx by laryngofissure to determine the size of the cancer. The size and position of the cancerous lesion in the larynx along with the grading of the biopsy specimen (Broder's classification) are of aid in selecting the surgical procedure to be used in the individual case.

In all cases of laryngeal malignancy, a careful search must be made for local metastases to neighboring lymph nodes and in all except the early cases distant metastases must be searched for. This should include roentgenograms of the chest and bones and careful neurologic examination for evidence of intracranial metastases. Distant metastasis is a contraindication to operative procedure.

It must be remembered that an individual is being treated, and the temperament, the wishes and desires of the patient must be individually considered as well as his general condition. Little is gained even if the operative procedure is successful if the patient remains a resentful, maladjusted invalid unable or unwilling to take his or her place in society. Great advances have been made by rehabilitation and speech training and very few patients remain maladjusted who attend postoperative classes for the laryngectomized individual.

Some patients are loath to undergo operative procedures which will alter their voices or necessitate a tracheal stoma, particularly if they think there is a chance of cure and at the same time of retaining their voices without mutilation. This is especially true of people who depend upon the voice for a living. There are those people who dread an operative procedure of any magnitude even though their life depends upon it. I have known a few who have refused operation knowing that in doing so, they would lose their chance to live.

Many patients with cancer of the larynx are 50 years or more of age. In the older age group there are patients who are suffering from severe cardiac disease or other diseases with very serious prognosis and a short expectancy of life, such as kidney disease with uremia, chronic alcoholism with marked liver damage or loss of liver function. Such patients may not be suitable operative risks. There are also a few quite old, frail, debilitated persons, already invalids, and a few who have no real desire to live and no spirit to accept any procedure which will make them well. Such patients are poor operative risks and are more suitably treated by radiation.

I believe that most patients with carcinoma of the larynx who have a chance for cure by treatment should be told of the condition. They should know the course of untreated cancer and that procrastination and delay decrease the chance of cure. Each individual should be told of the possibility of cure in his particular case so that he may intelligently make up his mind to accept this risk or to accept the consequences.

Radiation therapy by modern technics offers a high percentage of cure in the

early cases of laryngeal cancer, irrespective of grading. All patients are kept under close observation during and after treatment. When radiation therapy fails, these patients still have a chance of cure by adequate surgery. This chance, of course, is not as good as when surgery is the initial treatment. Clerf takes exception to this procedure and believes that radiation treatment should be given only when surgery is refused by the patient or contraindicated by the patient's condition.

Since surgery offers the best chance of cure, it must be given first consideration in treatment. The selected surgical procedure must be adequate; the lesion should be removed with a margin of healthy tissue about it. Except in early cases, the region of lymph drainage, which is likely to be involved by metastases, should be removed. It must be remembered that in any operative procedure, cures are not obtained by the operative procedure unless all the tumor is removed.

The simplest surgical procedure for laryngeal cancer is removal through the laryngoscope. Only when the diagnosis is made early, that is, at a time when the lesion is well localized and only a few millimeters in dimension, will this minor procedure be successful.

A second procedure is partial removal of the larynx through a laryngofissure. With this procedure it is essential that the sphincteric function of the larynx be retained, that is, the sphincter which prevents food and fluids from entering the trachea and bronchial tree must be preserved. If sphincteric function is destroyed it becomes necessary to occlude the lumen of the larynx and depend upon the tracheotomy for breathing purposes, or to remove the larynx entirely. The indications for partial laryngectomy have been fairly well defined.

Figi advocated the use of skin grafting in larger lesions otherwise considered suitable only for total laryngectomy. Skin grafting has enabled him to increase the indications for partial laryngectomy. Only laryngologists of wide experience should consider this procedure in carefully selected cases.

A third procedure, removal of the entire larynx, is employed when the laryngeal lesion is extensive but intrinsic.

The fourth procedure, removal of the larynx and contiguous structures with the lymph drainage area, is used when the carcinoma of the larynx has extended to the rim of or beyond the larynx to neighboring structures. In the last two instances the trend is toward more complete surgery.

Certainly, there is no advantage in saving nonvital tissue in the region of the neck if, in so doing, the life is lost because that tissue is involved by carcinoma When the larynx is removed by whatever method, its function is lost. The patient cannot breathe through the mouth and nose. Speech is lost until otherwise developed. Therefore, when the entire larynx is removed, the sparing of the prelaryngeal muscles, the leaving of the epiglottis or a part of it, the leaving of the pre-epiglottic space, the hyoid bone or a portion of the ring of the cricoid cartilage are to be condemned even in the so-called favorable case as a small percentage of these patients will have recurrence of the carcinoma in these tissues from carcinoma unobserved and unsuspected at the time of operation. When the lesion is subglottic, unless it is small, it is a good practice to remove one or two rings of the trachea as well as the larynx. The extent of the operative procedure is determined by the judgment and experience of the individual

operator. The most frequent mistake in the surgery of cancer is to do too little rather than too much.

Brachetto-Brian and Samengo emphasized the need for systematic prophylactic removal of the regional lymph nodes along with the larynx in all cases of cancer of the larynx when laryngectomy is done. They reported 100 patients in whom careful palpation of the neck before operation failed to reveal any evidence of enlarged nodes, yet when the patient was subjected to laryngectomy, at which time the carotid chain of lymph nodes was also removed for serial histologic study, metastases were found in 30 per cent. Two years after operation there was no evidence of recurrent carcinoma in any of these cases.

The cancer clinics in the United States do not advocate prophylactic nodal resection routinely in all cases in which laryngectomy is done. Node resections are not carried out in patients with favorable intrinsic lesions of the larynx. In the unfavorable or advanced cases in which the entire larynx is involved or in which the rim of the larynx has been invaded by the new growth, prophylactic node resection should be carried out on the side of greater involvement.

When removal of the lymph nodes and the lymph drainage area of the larynx is considered necessary, a complete operation should be performed, removing the nodes *en bloc*. This should include the tissues from the clavicle to the mastoid tip and base of the skull and from the skin to the prevertebral fascia, leaving only the common and internal carotid arteries along with the vagus, hypoglossal and spinal accessory nerves and sympathetic trunk, and these may be sacrificed in some instances if they are involved in the region of the metastatic nodes. The tissues removed include the platysma, the subcutaneous tissue, the sternomastoid, omohyoid and digastric muscles, the jugular vein with the carotid sheath, the lower portion of the parotid gland and the submaxillary gland and duct. A less complete procedure may be successful in many cases, but it is also true that carcinoma will be left in tissues outside the field of operation in some cases if only the nodes along the carotid vessels are removed without removal of the other tissues enumerated.

Arteriosclerosis, hypertension and diabetes can usually be so managed that they are no longer contraindications to the surgical procedure, yet vascular accidents are prone to occur in a number of such operated cases.

All patients who have had operations on the larynx for laryngeal carcinoma must return at regular intervals for careful examination, which must include inspection and palpation of the operative field with careful search for metastastic nodes in the neighboring lymph drainage areas.

If during the follow-up period metastatic nodes are found in the neck, the involved side should be completely dissected. Roentgenologic examination of the chest and bones and neurologic examination should be carried out before complete dissection of the neck is performed to determine whether distant metastases have become manifest since the previous examination.

REPORT OF CASES

Case 1. A man, 54 years of age, gave a history of hoarseness for three years and difficulty in breathing of six or seven months' duration. Respiration had been noisy and stridulous for about three weeks. The dyspnea had been so great that in recent

weeks he had been unable to lie down to sleep, and about four days before admission to the clinic suffocation seemed imminent. A laryngologist was consulted who immediately recognized the condition. He was greatly concerned because of the marked dyspnea, and referred the patient to the Lahey Clinic.

On admission, the patient was laboring for breath. Laryngeal examination revealed the circumference of the supraglottic larynx and glottis to be involved by an advanced malignant growth, with almost complete obstruction. A node was palpable over the cricothyroid membrane and firm nodes up to an inch in diameter were palpable in the right side of the neck underneath the sternomastoid and in the region of the spinal accessory nerve. The diagnosis of advanced carcinoma of the larynx was evident. Prelaryngeal metastases and metastases to the cervical lymph nodes on the right and possibly on the left side were present. The chest was normal on roentgenologic examination.

Intubation with an endotracheal cannula was performed to relieve the obstruction before the examination was completed. His general condition seemed good after intubation and warranted surgical intervention.

Complete dissection of the right side of the neck and laryngectomy were performed the evening of May 1, 1948. Almost all tissues from the clavicle to the base of the skull and from the skin to the prevertebral fascia and the brachial plexus were removed. The spinal accessory nerve was sacrificed because it lay in the group of carcinomatous nodes. The prethyroid muscles, hyoid bone and digastric muscle were also removed. The common and internal carotid arteries, the vagus and hypoglossal nerves were left intact The external carotid artery was ligated and its branches were removed. Following removal of the larynx the pharyngeal opening was sutured in the usual manner. A circular opening was made in the skin flap over the tracheal stoma and the trachea was sutured in place. During the operative procedure the patient received transfusions of blood (1000 cc.) and saline solution intravenously. Penicillin was given during and following the operative procedure. Healing about the tracheotomy tube and in the region of the pharyngeal opening was by primary union. A considerable quantity of serum drained from the wound for a period of nine days.

The patient was discharged to his home on the fifteenth postoperative day. He was examined at intervals by his laryngologist, and on July 28, 1948, nodes were palpated on the left side of the neck. On July 31 he again entered the hospital. Careful examination for distant metastases was made but none were found. A block dissection of the left side of the neck was done August 2. No adherent nodes were found and it was thought safe to leave the jugular vein as well as the carotid vessels and the vagus and spinal accessory nerves. He was discharged from the hospital on the sixth postoperative day. A total of twenty-four days in the hospital was required for these two procedures.

The pathologist's description of the specimen removed on May 1, 1948, was as follows: The specimen consisted of the complete larynx and a mass of fibrofatty tissue. The airway was almost completely occluded by a fungating crater-like mass largely on the right anterolateral wall and encircling all but 0.8 cm. of the interior circumference. The mass began at the base of the epiglottis and extended for 3.5 cm. downward, completely destroying the cords bilaterally and invading and destroying the anterior wall of the thyroid cartilage. The crater, largely on the right side, was 1.8 cm. in diameter. The fibrofatty tissue measured 10 by 8 by 3 cm. and contained large masses of striated muscle and a 3 cm. fragment of salivary gland. Throughout the mass there were numerous lymph nodes which measured from 1 5 to 2.5 cm. in diameter. Many of the larger nodes contained tan colored, granular, firm tissue. The



Fig 86. (Case 1) Anterior view, three years after first operation, showing deformity and lines of incisions following right radical neck dissection and laryngectomy, then left radical neck dissection. Incision lines extend from mastoid tip, curving below the angle of the jaw, upward past the midline of the chin and also below the angle of the jaw to the clavicle.



Fig. 87. (Case 1) Right side of neck three years after first operation (see Fig. 86).

microscopic diagnosis was epidermoid carcinoma, Grade 3, of the larynx, with metastases to six of twenty-eight lymph nodes.

[illegible] the second operation, August 2, 1948 [illegible]

nodes were isolated, one of which had a glistening, granular, white surface flecked with yellow. The microscopic diagnosis was epidermoid carcinoma, Grade 3, with metastasis to two of ten lymph nodes. The salivary gland was normal.



Fig. 88. (Case 1) Left side of neck three years after first operation (see Fig 86).

Figures 86, 87 and 88 show the patient's condition in April 1951, three years after his first visit. During this time he has been able to carry on with his business and has enjoyed life.

CASE 2. A man, aged 49 years, was first seen at the clinic on January 6, 1948 having been under the care of a laryngologist for about ten months. The cause of the patient's symptoms had not been recognized and the diagnosis of carcinoma at the base of the epiglottis was not made until metastases had occurred in the region of the bifurcation of the right carotid artery. He was referred to the clinic for treatment.

Physical examination was performed and the patient was considered to be a good surgical risk. Complete removal of the larynx and of the node-bearing region of the right side of the neck was urged as the treatment of choice. He refused operation because of the consequent deformity and loss of voice, but elected x-ray therapy.

A total dose of 7,200 roentgen units was delivered to the tumor and the metastatic nodes. Following therapy the tumor in the larynx and the nodes in the neck rapidly decreased in size. Although there was some radiation reaction, the metastatic nodules completely disappeared in so far as could be determined. The patient regained his voice and returned to work.

During the last week of July 1948 edema increased and there was evidence of

recurrence of the growth at the base of the epiglottis. Distant metastases could not be found. The patient was told that further x-ray treatment would be futile, and complete dissection of the neck and laryngectomy were again recommended. He was, however, unwilling to accept surgery. In September, a tracheotomy was done for relief of the increasing obstruction resulting from edema and growth. Following this procedure there was loss of voice and he requested operation. At that time, in addition to the recurrence in the larynx, new nodes had appeared in the right side of the neck. Distant metastases again were not evident, and radical dissection of the neck and laryngectomy were carried out. A portion of the pharyngeal wall and base of the tongue were found to be involved and were removed with the larynx. The cicatricial tissue and the tumor were so adherent to and compressing the carotid artery that it was considered safe to tie the common carotid artery. The artery was removed with the mass of tissue.

After operation the wound in the region of concentrated x-ray therapy broke down and a pharyngeal fistula developed. The fistula was closed by plastic flaps from the neck and shoulder. Four months later, in January 1949, the patient was able to return to work; he could swallow quite well and had developed a satisfactory esophageal voice. On examination May 4 he complained of some pain in the region of the shoulder. Roentgenograms revealed metastases in the chest and upper mediastinum. His condition rapidly deteriorated and he died five months later.

In this case it was realized that the chance of cure was slight, not more than 5 per cent by the complete operation, but the patient finally insisted on taking this chance.

These reports illustrate the extent to which surgical procedures can be carried out with comparative safety.

CONCLUSIONS

It is my belief that dissection of the neck will be considered a necessary accompaniment of all but the most favorable cases of carcinoma of the larynx for which laryngectomy is done. Local metastasis to the cervical lymph nodes will no longer be considered a contraindication for surgical removal by those who are prepared to do neck dissections.

Two cases are briefly presented.

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THE ESOPHAGUS, LUNGS AND HEART

ESOPHAGEAL DIVERTICULA AND THE TECHNIC OF THEIR REMOVAL

FRANK H. LAHEY

Esophageal diverticula divide themselves automatically into (1) the type and (2) the levels at which they occur. In order to discuss this subject satisfactorily, it is necessary to discuss the levels at which they arise since the types vary with the level of their occurrence.

There are three levels at which esophageal diverticula develop, the pharyngo-esophageal, the mid-esophagus at the level of the main bronchial stems and the supradiaphragmatic. The type of diverticulum occurring at the cricopharyngeal junction is a true pulsion type of diverticulum; the type occurring just above the diaphragm is also a true pulsion diverticulum and in both of these types the diverticulum is a false diverticulum and its sac is made up largely of mucosa and submucosa. On the other hand, the type of diverticulum occurring at the mid-esophageal level is a true diverticulum since its sac is made up of all of the layers of the esophagus, mucosa, submucosa and muscularis.

PHARYNGO-ESOPHAGEAL DIVERTICULA

If we discuss first pharyngo-esophageal diverticula, since they are most common, they are the type of diverticula that most frequently produce serious and disturbing symptoms and the type which most frequently come to operation. It is perhaps of the greatest importance to discuss the diagnosis of this type of diverticulum and to describe the technic which we have employed for its removal.

As may be seen in Figure 89, which has been employed a good many times by everyone who writes about this subject, the common point of origin of a pharyngo-esophageal pulsion diverticulum is the small triangular area bounded above by the lowest fibers of the inferior constrictor and bounded laterally by these fibers as they come obliquely down the back wall of the esophagus to meet in the midline by the cricopharyngei. This is the weak point in the esophagus at its junction with the pharynx and has been well named "the pharyngeal dimple."

A simple description of the mechanism of swallowing is the constricting action of the constrictor muscles of the pharynx, propelling the bolus of food into the esophagus where it is carried on to the stomach by gravity and by the constricting action of the esophageal muscular layer.

Like many other mechanisms in the human anatomy, this motion or propulsion of food from the mouth through the pharynx into the esophagus and thence on into the stomach is the result of a correlated and coordinated neuromuscular relationship. When this neuromuscular relationship is in normal coordination, as the inferior constrictors propel the food into the esophagus the

cricopharyngei muscles relax to admit the food into the esophagus. When, however, there is the slightest incoordination with any degree of obstruction brought about by neuromuscular incoordination resulting in closure of the crico-pharyngei fibers, there will then be the propulsion force exerted upon the weakest point in the pharynx, and that is the cricopharyngeal junction.

As can be seen from the above description, pharyngo-esophageal pulsion diverticula are brought about by the combined effects of a propelling force above, a constricting force below and the distention of the pharynx at a point where there is a weakness, that is, the pharyngeal dimple.

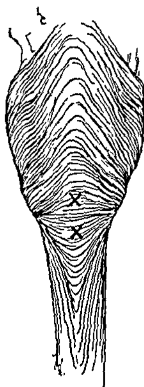


FIG. 89. The oblique separation of the cricopharyngei fibers from the inferior constrictor fibers is shown. It may be noticed in this frequently used diagrammatic illustration that there is a slight variation as to the point at which the sac of a pharyngo-esophageal diverticulum emerges, sometimes with a few fibers of the inferior constrictor below and sometimes only below the lowest fibers of the inferior constrictor.

It can immediately be seen that a pulsion pharyngo-esophageal diverticulum is quite comparable with an inguinal hernia. There is the propelling force of the intra-abdominal pressure, there is the weakness at the inguinal ring, but unlike the pharyngo-esophageal junction, there is no obstructing force below. An inguinal hernia results in the same kind of a single layer sac (peritoneum) as does the pharyngo-esophageal diverticulum with its single layer of mucosa and submucosa, perhaps lightly covered by a few attenuated fibers of the crico-pharyngei.

From the above description, one can set up, as shown in Figures 90 and 91, *a* and *b*, a diagram of the various stages of the development of a pharyngo-esophageal diverticulum. In Stage 1, shown in Figure 90, *a*, may be seen the simple bulge comparable with the original bulge in an inguinal hernia before there is extensive protrusion and the development of a sac. In Figure 90, *b* may

be seen Stage 2 in which the bulge has continued, increased in size and eventually produced, as in the inguinal hernia, a typical sac which is now a true diverticulum, a sac with a body and a neck, into which food goes and accumulates, there is stasis and all of the symptomatology which goes with this stage of the development of the diverticulum. As will be noted in Stage 2 (Fig. 90, *b*), when the sac of the pharyngo-esophageal pulsion diverticulum has not become large, the most important point in this stage of development of the diverticulum is the relationship of the aperture at the neck of the diverticulum to the sac or body of the diverticulum. This is important because it definitely relates to the

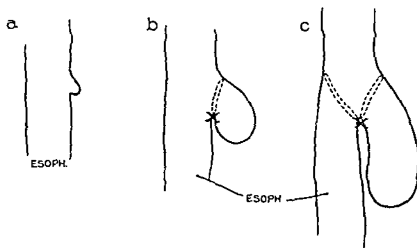


Fig. 90. *a*, In this diagrammatic outline of the first stage of development of an esophageal diverticulum is shown the mere bulge.

b, The second stage in which the opening into the diverticulum is still lateral, an example of which is demonstrated by the roentgenogram in Figure 91, *a*.

c, The beginning of the third stage of a pharyngo-esophageal diverticulum is shown in which the descent of the sac is gradually converting the opening into the sac into a transverse one and the opening into the esophagus into a lateral one, which is also illustrated by the roentgenogram shown in Figure 91, *b*.

symptomatology and the differentiation of the three stages of the development of the diverticulum, as will be discussed later.

In Stage 3, as illustrated in Figure 90, *c*, is shown the last stage of development of a pharyngo-esophageal pulsion diverticulum and, as already stated in discussing Stage 2, the most important feature in this stage of development of a pharyngo-esophageal pulsion diverticulum, as in Stage 2, is the relationship of the aperture from the esophagus into the diverticulum to the remaining portion of the esophagus (Fig. 90, *c*). Not only is this important in terms of symptomatology but, as shown in Figure 90, it is extremely important in terms of differential diagnosis from the type of dilatation which occurs above a constricting web of the esophagus.

The symptomatology of the pharyngo-esophageal pulsion diverticulum is mechanically related to the stage of the development of the diverticulum. In Stage 1, as shown in Figure 90, *a*, it is obvious that there can be no regurgitation, no obstruction, no accumulation within the sac, no gurgling from the mixture of air, mucus and fluid as occurs in the two latter stages and there can occur only the symptoms related to the occasional lodging of dry particles of

food, such as dry breakfast foods, dry crusts of toast and so forth, in the small bulge made when the diverticulum has developed to Stage 1. The symptoms of this stage then, as we have frequently written, consist only of the feeling of a foreign body in the throat and the hawking or coughing in attempting to remove it, and the symptoms are merely those of inconvenience in terms of the feeling made by this dry particle of food, but as soon as this is hawked up, there is complete relief of any symptoms.

In Stage 2, as shown in Figures 90, *b*, and 91, *a*, one now observes that with the development of a true sac, those symptoms which are associated with the accumulation of food taken at a previous meal mixed with mucus and liquids now present themselves. It is at this stage that patients complain that as they turn their neck from side to side and the tense belly of the omohyoid presses on the sac of the diverticulum which is directly beneath this structure, together with the sternomastoid and the edge of the sternothyroid, not infrequently there is expelled into the mouth a mixture of mucus and food of the character of that taken at a previous meal. It is at this stage also that patients not infrequently complain that they are awakened in the middle of the night as they turn their heads from side to side in their sleep, by the expulsion of the contents of this sac up into their pharynx, which frequently brings about coughing due to its inspissation, and awakens the patient. There have been four lung abscesses in our series now amounting to 330 operated cases as a result of this complication. Although this complication is not a common one, it is certainly an undesirable one and the danger of its occurrence is one of the indications for the removal of the diverticulum sac when it has reached either this second or third stage of development.

Another complication for which these patients frequently present themselves for surgery is the production of a noise at mealtime when they swallow, due to the fact that air becomes mixed with the mucus, fluid and food held within the sac. As the sac ascends and descends with swallowing and is pressed upon by the muscles over it, these patients frequently make a gurgling noise which is commented upon by their friends who are having lunch, breakfast or dinner with them. Not infrequently patients say, "I would like to have this diverticulum removed because I am so embarrassed to explain to all of my friends why there is a noise in my throat when I am having my meals with them."

At this second stage, as shown in Figures 90, *b*, and 91, *a*, it is obvious that since the opening into the diverticulum is directly lateral from the wall of the esophagus, and since the opening into the true esophagus is still in its normal position, that is, directly transverse as opposed to the opening into the sac which is oblique (see Fig. 90, *c*), obstruction never occurs, and the symptoms which cause patients to present themselves for surgery at this stage are not related to their inability to ingest food, weight loss, or any inconvenience as to the ability to get food into their stomachs.

In Stage 3, all of the symptoms of Stage 2 occur, that is, regurgitation of food, being awakened at night, the production of a gurgling noise on swallowing, plus varying degrees of obstruction up to almost complete obstruction, with extreme weight loss and emaciation.

The mechanics of the obstruction which occurs in the third stage of esophageal

diverticula are well shown in Figures 90, c, and 91, b. It is to be noted in these illustrations that as the sac becomes larger, it always descends into the mediastinum; as it becomes larger it is progressively distended and as the result of the traction associated with ascending and descending with swallowing, the opening at the neck of the diverticulum is no longer oblique but is almost completely transverse (Fig. 91, *b*), and since the traction of the large food-filled sac is downward, its opening is converted into a transverse one but the opening into the true esophagus, as shown in illustrations 90, *c*, and 91, *b*, is converted into a lateral one. It is this traction of the sac downward that brings about



Fig. 91. *a*, This is an actual roentgenogram of Stage 2. It is to be noted that the opening into the diverticulum is directly lateral from the wall of the esophagus and not transverse, as is present in Stage 3 shown in Figure 91, *b*.

b, In this illustration is shown the advancement of the diverticulum to Stage 3. In the insert (*c*) is shown diagrammatically what is so well illustrated by the roentgenogram. Note that at this stage the opening into the sac of the diverticulum is transverse and the opening into the esophagus is lateral. The roentgenogram demonstrates this feature.

It is to be remembered that no roentgenogram of a diverticulum can demonstrate that it is truly a pulsion diverticulum and not a dilatation of the esophagus above a web unless the spillover from the filled sac can be shown as coming from the top of the sac and passing laterally down beside or behind it, as shown in this illustration (Fig. 91, *b*).

the esophageal obstruction, the inability of patients to ingest an adequate amount of food and the emaciation and inanition which go with the inability to get enough food through the oblique opening into the true esophagus. It is further to be noted in the mechanics of the obstruction which goes with esophageal pulsion diverticula of the pharyngo-esophageal type that in the third stage, the heavier and larger the food-filled sac becomes, the greater is the traction upon the lateral opening into the true esophagus until the two lips of the opening into the esophagus are pulled together most of the time, narrowing the opening and cutting down the amount of food which can pass through it into the stomach for nutrition (Fig. 91, *b*).

It is in the third stage that we wish particularly to warn against the dangers of attempting to pass a bougie or esophagoscope. At the third stage it is practically impossible to introduce an esophagoscope due to the fact that the rigid

tube-like inflexible wall does not permit manipulation of the esophagus so that it can be introduced into what is now a lateral opening in the true esophagus. It is also in this stage that we wish to warn against passing a bougie. We have had 4 cases in which attempts, elsewhere, to pass a bougie and dilate the esophagus have resulted in perforation through the tip of the sac since, as with the esophagoscope, the bougie, when passed, goes directly into the diverticulum sac and cannot be manipulated into the lateral opening into the true esophagus. It is in these cases that we have seen perforation and mediastinitis, and when the roentgenogram, as shown in Figure 91, *b*, and diagrammatically in Figure 90, *c*, demonstrates the lateral position of the aperture into the true esophagus, attempts to either esophagoscope or bougie such patients are associated with high risks of perforation.

With the last two stages of esophageal diverticula there are other associated symptoms which make early removal of such sacs desirable. It is not infrequent for patients with esophageal diverticula of the pharyngo-esophageal pulsion type to be annoyed by constant cough due to the spilling over of food at night, nor is it infrequent for infiltration to occur into the bronchial roots due to the infection secondary to the spilling over and inhalation of moderate amounts of food and mucus. A not uncommon complication seen in those patients who are addicted to mineral oil is the infiltration of oil beneath the alveolar mucosa at the lung roots where accumulations of mineral oil within the sac have spilled over during the night and day, have gravitated into the bronchi and have resulted in the typical roentgenologic picture of deposits of this material in the lung roots.

The operative treatment of pharyngo-esophageal pulsion diverticulum used to be associated with mortality and morbidity rates which were forbiddingly high. The development of operative procedures for this type of diverticulum has now advanced to the stage where reasonable and limited morbidity and operative mortality rates have been attained.

We have now operated upon 330 esophageal diverticula, of which 9 have been of the supradiaphragmatic intrapleural type and 321 of the pharyngo-esophageal type. All of these operations have been done in two stages, the mortality rate for the entire series being 0.6 per cent, that is 2 fatalities in the 330 cases. The first fatality occurred in a man of 84 years, in the first series of 20 cases in the earliest days of our experience. This patient died on the third day of uremia; there was no mediastinitis and no perforation of the sac and his death was only indirectly related to the operation for his diverticulum. The second death occurred in a doctor over ten years ago, in whom the posterior neck of the sac was perforated, was unrecognized at the time, resulted in a mediastinitis which was not recognized until the third day, with empyema, mediastinitis and eventual death. This complication occurred at a stage when antibiotics or the sulfon drugs were not available and was the direct result of a technical error. There have been not only no fatalities since that time but also practically no morbidity. There are no discharging sinuses and a recent follow-up study of this group of cases has demonstrated but 9 recurrences, most of these having occurred in the early stages of our experience with this operation.

A heated debate has not infrequently occurred in papers dealing with this subject as to whether these operative removals of pharyngo-esophageal pulsion

diverticula should be done in one or two stages. All of these cases have been done in two stages. Exclusive of the case in which a hole was cut in the sac, there have been no cases of mediastinitis or empyema, there have been no discharging sinuses which have persisted, it has not been necessary to do gastrostomies, to open necks and to pack fascial planes, and there has been a very limited number of recurrences.

Since with the two-stage procedure these patients can be discharged from the hospital on the fourteenth day, able to swallow well, since one can be completely relieved of any fear of the danger of fascial plane infection or mediastinitis, since regardless of whether or not the removed sac, which has either been sutured or ligated at the neck, leaks, a serious problem will not be created, we will continue indefinitely to employ the two-stage rather than the one-stage procedure.

The decision for or against one or two-stage procedures must be a personal one, but one must recognize at least that decisions for or against a certain type of operative procedure must, in this type of procedure, inevitably be based upon three very important demonstrable factors: what are the fatality percentages, what are the morbidity percentages and what is the recurrence rate? At least in this series I know of no comparable figures with the mortality rate as low, no comparable figures with the morbidity rate as low, although morbidity has not been reported in many articles on this subject, and no recurrence rate which is any lower than with this operation done in two stages.

We are strongly in favor of two-stage removals not only for the above reasons but because the only difference between the one-stage procedure and the two-stage procedure is that the patient must receive gas anesthesia at the second stage for the ligation of the neck and removal of the sac.

It seems unwise to us to discharge a patient following a one-stage procedure until one can be entirely sure that there will be no leakage at the neck of the sac where it is either ligated or sutured. From our experience in doing these operations in two stages, we would not dare to discharge a patient earlier than the twelfth or fourteenth day because we have seen leakage occur as late as this, and we would not dare to have such a patient where he would not be under direct observation and where immediate drainage of the fascial plane could be undertaken.

As shown in Figure 97, *b* and *c*, in the second-stage ligation of the neck of the sacs of these diverticula or the inversion and reinforcing suture in those patients in whom the neck has been unduly large, too large for ligation, most of the cases close without incident and without leakage, but occasionally, even in the patient with a small diverticulum sac, with an excellent neck for ligation that has been accurately tied off, there will be leakage. If this occurs in a patient who has a two-stage operation, one has no apprehension or worry whatever. The fistulous tract will eventually close, the fascial planes have been walled off and one can have complete assurance that there will be no serious complications such as mediastinitis or empyema.

I am quite willing to grant that with modern methods of exposure, accuracy of ligation, with the use of sulfon drugs and antibiotics, should leakage occur, it can in most instances be dealt with safely. I do not believe as the result of

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The decision for or against one or two-stage procedures must be a personal one, but one must recognize at least that decisions for or against a certain type of operative procedure must, in this type of procedure, inevitably be based upon three very important demonstrable factors: what are the fatality percentages, what are the morbidity percentages and what is the recurrence rate? At least in this series I know of no comparable figures with the mortality rate as low, no comparable figures with the morbidity rate as low, although morbidity has not been reported in many articles on this subject, and no recurrence rate which is any lower than with this operation done in two stages.

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I am quite willing to grant that with modern methods of exposure, accuracy of ligation, with the use of sulfon drugs and antibiotics, should leakage occur, it can in most instances be dealt with safely. I do not believe as the result of

this relatively large experience with pharyngo-esophageal pulsion diverticula that the hazards of fascial plane infection or mediastinal infection and the complications, however slight, that go with the one-stage as compared with the two-stage operation are worth the added risks. The period of hospital stay is little

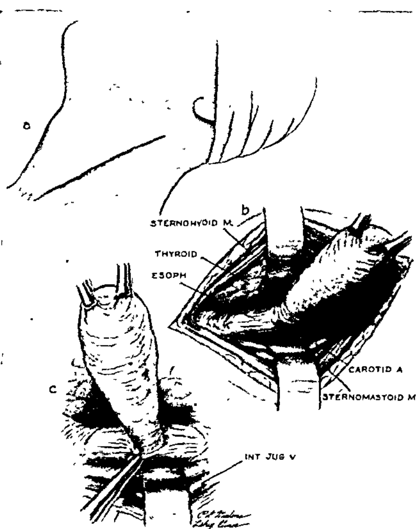


Fig. 92. *a*, The longitudinal incision in front of the sternomastoid. This provides exposure of all the anatomical structures much more completely and adequately than does a goiter incision.

b, This illustration shows the thyroid gland already freed from the internal jugular, lifted up by a retractor and rotated inward. The anterior belly of the omohyoid has already been removed, the longitudinal fibers of the true esophagus are shown, the neck of the esophagus is well dissected and its relationship to the common carotid artery, internal jugular vein and sternomastoid muscle is apparent.

c, In this illustration is shown the complete separation of all of the fibers of the cricopharyngei from around the neck of the sac until the sac is so completely dissected that it hangs entirely by its neck. This makes possible ligation of the neck flush with the esophagus at the second stage.

if any shorter. There are no more recurrences, if as many, with the two stage than with the one-stage procedure, the inconvenience to the patient of the second anesthesia is slight, and if the second stage of the operation is done in seven days the wound heals kindly and without complications.

In discussing the technic of operations for pharyngo-esophageal diverticulum

(Figs. 92 to 97) we would first like to urge strongly that such is the anatomy in the region where esophageal pulsion diverticula of the pharyngo-esophageal type occur, behind the thyroid, underneath the inferior thyroid artery in close proximity to the recurrent laryngeal nerve, at a point where the esophagus is fixed to the pharynx and so it is impossible to rotate it satisfactorily for exposure, the incision should be of such location and length that the anatomic structures may be well exposed under good light and injuries to any of these structures avoided.

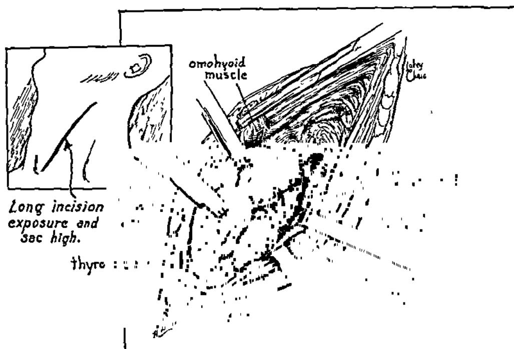


Fig. 93. This diagrammatic illustration demonstrates further details of the exposure of the sac. The longitudinal incision is shown in the insert. In the main illustration may be seen the thyroid gland pulled forward, the belly of the omohyoid held above, later to be tied and cut away, the sac of the diverticulum beneath the inferior thyroid artery, the inferior thyroid artery in most cases of esophageal diverticulum must be severed and ligated, and the retracted common carotid artery and internal jugular vein. (From: Lahey, F. H.: Esophageal diverticula. Arch. Surg. *41*:1118–1140 [Nov.] 1940.)

We believe that the need for light and exposure is best met by disregarding the location of the scar in terms of appearance, such as with the goiter scar, and best met by a long longitudinal incision directly in front of the belly of the sternomastoid.

With this type of incision, dissected back as shown in Figure 92, *a*, *b*, and *c*, the sternomastoid can be separated back, the external border of the sternohyoid demonstrated and the anterior belly of the omohyoid clearly brought into view (Fig. 93). The removal of the anterior belly of the omohyoid has been a very valuable addition to this step of the operative procedure, and has been employed for a number of years. As soon as the anterior belly of the omohyoid is removed, the descending branch of the hypoglossal nerve immediately comes into view, the internal jugular vein and common carotid artery are visualized and the outer edge of the thyroid gland becomes evident. The venous channels connecting the thyroid gland with the internal jugular, superior, middle and inferior, can be

severed, a retractor placed beneath the thyroid gland and the gland elevated. The common carotid and internal jugular are retracted back and the inferior thyroid artery visualized (Fig. 93). The inferior thyroid artery is caught between clamps, cut and doubly ligated, thus making it possible to so elevate the thyroid itself that the diverticulum immediately comes into view, the longitudinal esophagus is demonstrable, and the lowest limits of the sac, if it is not a large one, can be demonstrated. If it is a large sac extending into the mediastinum, the lateral wall of the sac can be separated from the true esophagus and the fascial plane into the superior mediastinum demonstrated so that the large mediastinal diverticulum sac be gradually separated from the true esophagus, pulled up and completely delivered.

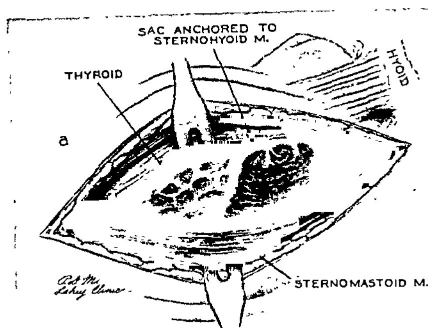
One of the first steps of the operation for pharyngo-esophageal pulsion diverticulum is the prevertebral fascia layer. It is this layer which must be separated back and freed up to and beyond the pharyngo-esophageal junction and downward into the mediastinum so that at least some degree of rotation of the esophagus at its upper point where it is attached to the pharynx is possible, thus making visualization of the neck of the sac easier.

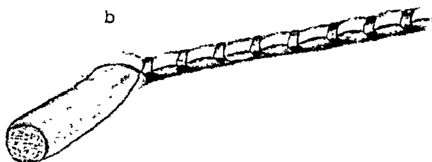
As shown in Figure 92, *b*, with the inferior thyroid cut and tied, one must then either demonstrate or feel the recurrent laryngeal nerve in order to be sure of its location and to be certain that it is not injured in the dissection of the sac. It is to be remembered that the lowest fibers of the inferior constrictor are attached to the horn of the thyroid cartilage and that the point of entrance of the recurrent laryngeal nerve into the larynx is beneath the lowest fibers of the inferior constrictor, the point at which the esophageal diverticulum originates. It is true that the recurrent laryngeal nerve enters the larynx anterior to the point where most esophageal diverticula originate, but not all esophageal diverticula come through at the cricopharyngeal junction and not always exactly in the middle line in back. It is for this reason that it is important to know where the recurrent laryngeal nerve is, either by inspection or palpation, so that care can be taken to avoid it.

The diverticulum sac is now grasped with Babcock holding forceps (Fig. 92, *b* and *c*) and its sac is progressively separated from the true esophageal wall up to the point where the sac enters the esophagus (Fig. 92, *c*). It requires good light, delicate dissection, and persistency to free the sac of the diverticulum completely up to the point where it enters the true esophagus, that is, at the point where its neck is developed. As shown in Figure 92, *b* and *c*, at point "X," this dissection is important because if the neck of the diverticulum is not completely separated from the longitudinal esophagus so that its acute angle is converted into an obtuse one, there will be left a small portion of the neck of the sac adherent to the longitudinal esophagus. When the second stage is done, this incomplete removal of the neck will result in a ligature being placed about what is thought to be the true neck of the sac, but there will remain still a portion of the neck undissected so that a small sac will exist, to bring about a recurrence of the diverticulum. We are sure that this incomplete dissection of the lower angle of the sac where it is attached to the longitudinal or true esophagus is the cause of a large number of recurrences in operations for pharyngo-esophageal pulsion diverticulum We are equally sure that

it is a dangerous point in the dissection because of the ease with which the esophagus could be entered here.

The principle of complete mobilization of the diverticulum sac with accurate ligature of the sac flush with the wall of the true esophagus (Fig. 97, *a*, *b* and *c*)





[illegible] pex of the sac of the diverticulum to [illegible] one could assume that the stitches [illegible] m. They have picked up only the adventitious tissue and have not penetrated the mucosal lining

It is to be noted, as will be shown in Figure 96, *b*, that these black silk stitches with the ends left long will serve to identify the sac at the second stage.

b, This shows the closure of the wound following the first stage procedure, with a cigarette drain introduced into the mediastinum and coming out at the lower end of the incision.

is of equal if not greater importance than is this principle in the ligature of those sacs which occur in inguinal or femoral hernias.

It is to be remembered that a pharyngo-esophageal pulsion diverticulum is a false diverticulum in relation to the walls of its sac. The walls of the sac are made up largely of the mucosa and submucosa. I would like to state that, from our experience, no dissection of the sac of a pharyngo-esophageal pulsion diverti-

culum is complete unless the pale external side of the submucosa of the neck of the sac can be demonstrated as completely freed from all muscle fibers about the sac, and particularly at its lower angle, as shown in Figure 95, *a* and *b*. Whether or not the sac can be accurately ligated flush with the esophagus at the second stage is dependent very largely upon how thoroughly the muscle fibers have been dissected from the wall of the sac at the first stage of the operation.

I would particularly like to call attention to the hazards of dissecting the muscle fibers from the back wall of the sac because of the difficulty of exposing this wall to direct vision as the diverticulum sac is pulled out due to the fact that the very upper limit of the esophagus where it is attached to the pharynx does not permit of such rotation as to make this exposure satisfactorily possible. The front layers of muscle can be dissected from the neck of the sac, those at the upper angle and at the lower angle, but we prefer to delay the removal of the muscle fibers from the posterior neck of the sac until the second stage of the operation. At the second stage done in seven days, the fascial planes have become walled off, the mediastinum has become walled off from having been packed with a cigarette drain, and should the posterior neck of the sac be inadvertently opened at this stage, no complications of serious consequence will occur. It is at this point that the esophagus can be opened as a result of inadequate exposure, the surgeon not be aware of it and close the neck with the feeling that there will be no leakage, only at a late date to realize that a nick has been made in the sac at this obscure location which has resulted in infection of the fascial planes and the mediastinum. It was this error that brought about one of the two fatalities which have occurred in this series of 321 cases of the pharyngo-esophageal pulsion type of diverticulum.

With the neck of the sac completely dissected below, in front and above, we have then attached the sac to the upper and outer fibers of the thyrohyoid muscle, as shown in Figure 95, *a* and *b*. This has served the very useful purpose of making it easy to identify the sac at the second stage operation. It is important in anchoring the neck of small and medium sized sacs to the outer edge of the upper portion of the sternohyoid to employ care not to introduce the needle that anchors the sac through all of the wall of the diverticulum. If this is done there will be leakage, wound contamination and undesirable conditions. We have avoided this complication by picking up with a hemostat the adventitial tissue about the sac, as shown in Figure 95, *b*, tying a black silk suture around it, to which is attached the needle, and then suturing this stitch to the outer border of the sternohyoid. This fixes the apex of the sac usually at a higher point than the neck, food does not enter the sac in the seven-day interval between the first and second stages of the two-stage procedure, there is no interference with swallowing, these patients can be fed on the afternoon of the operation, and at the second stage if the sac is thus attached with black silk stitches laid down on the anterior border of the sternohyoid, as shown in Figure 94, *a*, the sac is readily identified.

Following the first stage mobilization of the sac and fixation to the outer border of the sternomastoid, an indwelling feeding tube is not employed. These patients are permitted out of bed on the afternoon of the operation. They are placed on a full diet during the seven-day interval between the first and second

stage. A cigarette drain is introduced, as shown in Figure 94, *b*, at the lower end of the wound and carried into the superior mediastinum to produce walling off

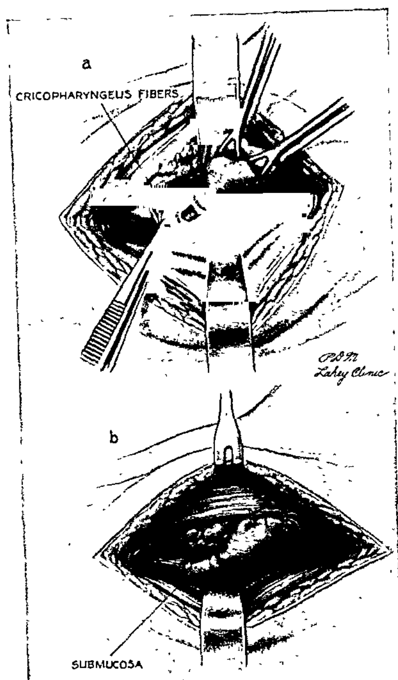


Fig. 95. The complete dissection of the neck of the diverticulum is shown in *a* prior to its being sutured to the edge of the sternohyoid muscle. Note in both *a* and *b* that the muscularis has been completely removed so that only the pale white reverse side of the submucosa appears at the neck. This is important since when this is done one can be sure that all muscle fibers about the neck of the diverticulum have been completely dissected. In *b* is shown the anchoring of the sac to the sternohyoid muscle.

of granulations in this cavity. The wound is closed with interrupted catgut stitches to the platysma and clips to the skin.

The second stage procedure of the two-stage operation for esophageal diverticulum used to be delayed until the twelfth day. These procedures are now

done on the seventh day in all cases. By the seventh day there is adequate sealing off of the fascial planes and the mediastinum and the wound reopens easily. If one waits twelve days, the wound healing is so firm that separation of the lines of cleavage is not as easily accomplished as when the wound is reopened on the seventh day, and is associated with more bleeding from the granulations then present.

As shown in Figure 96, *a*, the wound is very easily reopened by separating the skin and platysma, and then introducing one's finger into the tract left by the drain which has been removed on the fourth or fifth postoperative day of the first stage of the procedure. The finger is carried up in front of the sterno-

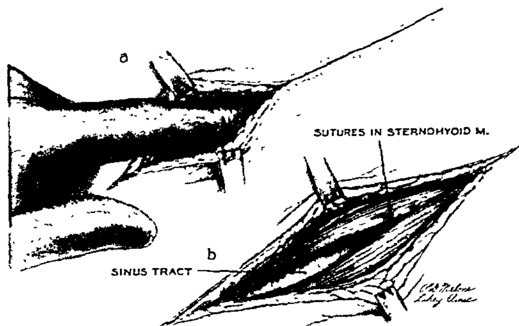


Fig. 96. *a*, The reopening of the wound at the second stage is illustrated. Note the finger has been introduced into the sinus tract left by the drain which is removed on the fourth day. *b*, The separation of the wound by traction on double hooks applied to the edge of the wound. The black silk stitches are shown on the edge of the sternohyoid, indicating the point at which the sac of the diverticulum has been fixed to this muscle.

mastoid and it is to be remembered that the posterior aspect of the wound which is separated from the thyroid and from the sac of the diverticulum in the second stage is made up of the internal jugular and common carotid artery. In seven days these are usually well fused together, and as they are separated back it is wise to remember that either finger separation or retraction on these structures must be gentle because of the possibility of injury, particularly to the internal jugular vein. This warning is stated not because such a complication has occurred frequently, only once in our experience has the internal jugular vein been injured in the second stage and this was because a nurse applied undue pressure upon the internal jugular vein with the point of a retractor.

With the wound widely opened, with a good light, and with the edges of the wound well retracted, the outer border of the sternohyoid muscle can be demonstrated, the black silk stitches which have fixed the sac to its outer border can

be followed up to that point, they can be freed and the sac can be picked up with tacking forceps (Fig. 96, *b*). If the diverticulum sac is a large one, the procedure of anchoring the sac to the prethyroid muscle is impractical and in such cases the sac is implanted in the wound. In such a type of sac anchored in the wound, the second stage operation corresponds with the management of the smaller sac except that the wound is reopened about the sac implanted in it and its neck demonstrated and dissected as with a smaller sac.

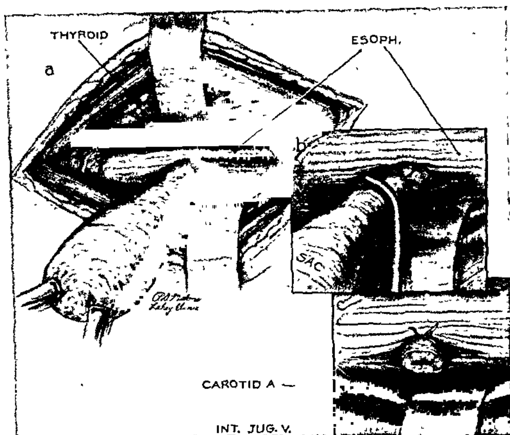


Fig. 97. *a*, The complete dissection of the neck of the sac is shown. The ligature can now be placed flush with the true esophagus so that no sac remains to promote a recurrence.

b, The plan is illustrated of applying the right angle clamp to the neck of the sac at some distance from the ligature to be sure that the ligated neck does not slip through the tie and soil the wound with esophageal content.

c, The amount of sac is shown which remains beyond the ligature to be sure that the ligature does not slip off.

With either the large or the small sac, following the separation of the sac from the prethyroid muscles to which it has been attached if a small sac, or from the skin into which it has been implanted if a large one, the neck of the sac is carefully wiped out in front, below and above, until the pale submucosal layer demonstrated in the first operative procedure is clearly visible. The sac is then carried forward and the posterior attachments of muscles which were not freed at the first stage of the operation are now carefully separated. With these separated, the neck of the sac is now made up entirely of mucosa and submucosa.

It is important at this stage to demonstrate, particularly at the lower angle of the sac, whether or not there are some sling fibers of muscle just beneath the point where the sac comes off the true esophagus. If they are present, they

are separated with a right angle clamp and severed so that there are no angulating fibers at this point to interfere with accurate ligature or suture of the neck of the sac where it joins the longitudinal esophagus in an attempt to prevent leaving even a small neck of the diverticulum sac to bring about a recurrence.

With the neck of the sac made up now entirely of mucosa and submucosa, completely freed of muscularis, if the sac is small and the neck not of too great caliber, it can be accurately ligated with chromic catgut (Fig. 97, *a*, *b* and *c*). Great pains must be taken to be sure with this ligature, which is not easy to place and one must be aided by someone holding the ligature about the right side of the neck of the sac, that the sac is tied off flush with the esophagus. It has been our custom usually to ligate the neck of the sac twice to be sure that the knot is well set down about the neck of the sac.

An extremely important point in the technic of ligature of the sac is shown in Figure 97, *b*. In small or medium sized sacs the neck of the diverticulum sac should be clamped distal to the tie to prevent spilling of the contents of the sac. It is important that this clamp be put on at such a distance from the ligature about the neck of the sac that there is no danger of the sac's neck slipping off. If the neck of the sac is cut too close to the ligature, the tie can easily slip off, resulting in great difficulty in recovering it and suturing it or religating it. If a good-sized section of sac distal to the ligature is left (Fig. 97, *c*), it will in no way interfere with the safe healing of the sac, but will with much greater certainty avoid the possibility of this accident.

When the neck of the sac is large it can be severed completely, the edges of the sac being picked up with tacking forceps, and the large opening into the esophagus can then be accurately closed with in, out and over inversion stitches and a second reinforcing set of mattress stitches of chromic catgut can be inserted.

Following the ligation or the suture of the neck of the sac after the sac has been removed, a cigarette drain is introduced again into the fascial planes and the mediastinum, the platysma is again sutured with single number 0 catgut and the wound is closed with clips. The drain is removed on the fourth day.

An important item in the second stage operation is the passage of a Levin indwelling tube into the esophagus. Usually the anesthetists can introduce this tube before the operation so that it is already in the stomach at the time the sac is removed at the second stage of the operation. There will be occasional cases, however, in which the tube will not readily pass into the true esophagus and then on into the stomach. In such cases it has been my custom to aid the passage of the tube before the sac is opened by manipulating it past its neck, and if this is not possible, to open the sac, to pick up the Levin tube in a right angled hemostat and to pass it directly down into the true esophagus where, after it has once been engaged in the lumen of the true esophagus, the anesthetist can pass it on into the stomach.

It has been of advantage to feed these patients through an indwelling gastric tube for the seven-day interval that these patients are hospitalized following the second stage of this procedure. This has the advantage of putting the esophagus relatively at rest, the patients are assured of adequate fluid and food intake, and at the end of seven days the tube can be removed without risk.

There has been a very limited number of cases in which leakage has occurred after the removal of the tube at the end of seven days and there have been no cases in which any permanent sinuses have resulted.

At the beginning of our experience with this operative procedure, a bougie was passed postoperatively in many of these cases but in the latter half of these experiences it has not been necessary to carry out these procedures.

SUPRADIAPHRAGMATIC PULSION DIVERTICULA

Supradiaphragmatic pulsion diverticula as shown in Figure 98 are not a common type of diverticula. We have had 9 of these in our experience. Of the 9,



Fig. 98. This roentgenogram shows very well an example of the supradiaphragmatic pulsion diverticulum.

3 have been treated by suspension, the plan of which is diagrammatically shown in Figure 99, *b*, 3 have been treated by transthoracic resection of the diverticulum and 3, as shown in Figure 99, *c*, *d* and *e*, because they have produced narrowing of the esophagus at this point, have been treated by transthoracic resection of the esophagus including the diverticulum.

Supradiaphragmatic pulsion diverticula are false diverticula with protrusion of the mucosa and submucosa through the muscularis of the esophagus. With the chest opened and with these diverticula demonstrated, particularly at their neck, the thick fibers of the muscularis of the esophagus may be shown completely surrounding the neck and the wall of the diverticulum itself is made up largely of mucosa and submucosa, as in the pharyngo-esophageal diverticulum.

The symptomatology of supradiaphragmatic pulsion diverticula is made up of two features, one the result of the accumulation of food within the sac, which has become decayed, produces a foul odor and a bad taste, resulting in nausea and a general unhappiness, not infrequently with local pain as a result of this occurrence. The other set of symptoms associated with this lesion is secondary

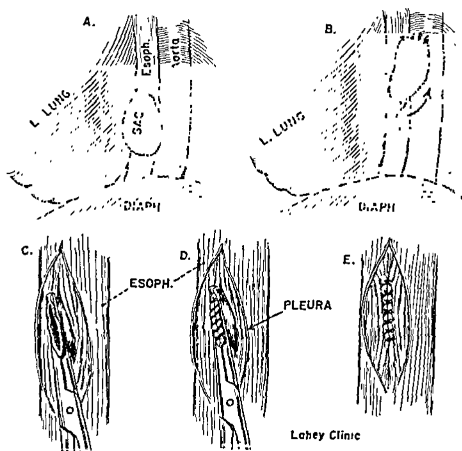


Fig. 99. In *A* is shown diagrammatically the supradiaphragmatic pulsion diverticulum, as illustrated by the roentgenogram in Figure 98.

In *B* is shown the method of completely dissecting the neck of the sac and suturing it to the parietal pleura at a point parallel with the esophagus and higher than the neck of the sac.

In *C* is shown the method of clamping the neck of the sac, three clamps being put on, the sac severed wi[illegible]
then removed and [illegible]
and submucosa, s[illegible]
silk sutures as shown in *E*.

to cicatrization and narrowing of the esophagus about the neck of the diverticulum and the mechanical obstruction which results.

In Figure 99 may be seen the approach to this lesion transthoracically; most of such cases have been done by Dr. H. D. Adams and Dr. D. P. Boyd, who are in charge of the department of thoracic surgery in this clinic.

In Figure 99, *B*, is shown the method of suspending such a supradiaphragmatic esophageal diverticulum.

When excision, the most desirable method, is to be done, the inferior pulmonary ligament is severed, the lung is held out of the way with retractors and

wet packs, and the diverticulum sac and neck are completely dissected and isolated until the sac hangs entirely by the attachment of its neck to the true longitudinal esophagus. Two clamps are then applied to the neck of the sac flush with the true esophagus. The third clamp is applied just beyond the second one and the neck of the diverticulum cut away with the cautery between the distal and middle clamps. By this plan a practically aseptic resection of the neck of the sac with inversion of the neck into the longitudinal esophagus can be obtained (Fig. 99, D and E). It is to be noted that as the two clamps are placed on the inner aspect of the neck of the sac, an aperture is left between the median one and the distal Ochsner clamp which shuts off the sac from any leakage. The tissue between these two clamps is severed with the electric cautery and the inner edge of the sac completely sterilized. The distal clamp of the two inner clamps is then removed, leaving a cuff of cauterized tissue which can be sutured over and over with a running suture of number 0 catgut (Fig. 99, *D*). The inner clamp is then removed, the over and over suture is pulled up tight and the remaining segment of crushed esophagus representing the inner aspect of the neck of the sac is then buried into the wall of the esophagus with a continuous returning layer of the original catgut suture. The whole structure is then buried by sutures of silk (Fig. 99, *E*) and a practically aseptic resection of the neck of the esophagus acomplished. A catheter is left coming out of the pleural cavity to drain it and the wound is closed in layers.

In those cases in which, as a result of an inflammatory reaction within the sac and about its neck which has caused narrowing of the esophagus, the typical transthoracic resection of the lower end of the esophagus has been done by the thoracic surgeons in the clinic, the stomach brought up into the thoracic cavity to compensate for the loss of esophagus and the typical anastomosis of the esophagus to the stomach done.

There have been no deaths in this series in those cases in which the sac has been mobilized and suspended parallel to the esophagus, as shown in Figure 99, *B*, and there have been no recurrences and no complications in the three operations of this type.

TRACTION DIVERTICULA

The remaining type of esophageal diverticulum to be discussed is the traction diverticulum, an example of which is shown in Figure 100.

Esophageal diverticulum of the traction type occurs as the result of the esophagus becoming adherent to inflammatory bronchial glands at the level of the main bronchial stem. Secondary to the organization and cicatrization occurring in these glands when the inflammatory process resolves, there has been retraction of the esophagus which results in the production of a true traction diverticulum with all of the true layers of the esophagus.

It has not been necessary to operate upon any of these patients since most diverticula of this type, possessing as they do all their muscular wall, are able to empty themselves. Surgery has not been necessary in these cases, likewise, because most of the traction upon such traction diverticula has been either lateral or upward. There have been no dependent sacs similar to those which

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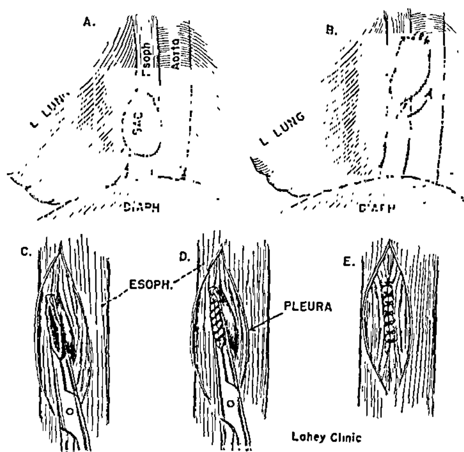


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It has not been necessary to operate upon any of these patients since most diverticula of this type, possessing as they do all their muscular wall, are able to empty themselves. Surgery has not been necessary in these cases, likewise, because most of the traction upon such traction diverticula has been either lateral or upward. There have been no dependent sacs similar to those which

are found in pharyngo-esophageal diverticula or the diverticula of the pulsion type occurring above the diaphragm. These cases have been handled very satisfactorily by dilatation and in none of the cases that we have seen of this type have there been either the symptoms associated with the false diverticula of the



Fig. 100. This roentgenogram demonstrates the typical traction diverticulum. Note the lack of dependent position. It is to be recalled that these are the result of traction of inflammatory bronchial glands which have become adherent to the esophagus. These diverticula rarely, if ever, require removal.

pulsion type as the result of dependent accumulation of food within the sac, or obstruction.

CONCLUSIONS

This discussion has dealt with the three types of esophageal diverticula: pharyngo-esophageal pulsion diverticula, the pulsion diverticula occurring just above the diaphragm, and traction diverticula.

The pharyngo-esophageal diverticula have been discussed from the point of view of the three stages and the symptomatology and complications associated with each stage The pulsion diverticula occurring above the diaphragm have been discussed, together with their symptomatology, as in the case of the pharyngo-esophageal diverticulum. The technical procedures employed in the management of both of these types of pulsion diverticula have been discussed and illustrated. There have been 330 cases of pulsion diverticula, of which 9 occurred at a location just above the diaphragm. There have been, therefore, 321 pharyngo-esophageal diverticula. Two deaths have occurred in the surgical

management of pharyngo-esophageal diverticula. There have been no deaths in the 9 cases of pulsion diverticula occurring just above the diaphragm.

The two-stage procedure employed regularly in this clinic is described and illustrated.

Traction diverticula have not required surgery and have been managed quite satisfactorily by dilatation.

THE SURGICAL MANAGEMENT OF OBSTRUCTING LESIONS OF THE ESOPHAGUS

HERBERT D. ADAMS

Since the esophagus and the stomach are so closely associated physiologically, pathologically and at the present time surgically with increasing frequency, any surgical discussion of one of these structures must necessarily include some surgical aspects of the other. I wish to confine this discussion to the practical clinical management of the surgical lesions of the esophagus and the proximal end of the stomach, and to the surgical technical details which have considerable bearing on obtaining good end results.

Some years ago at a stage of the development of esophageal surgery (with the exception of procedures on the cardia and the lower end of the esophagus) when we did not have the protection of antibiotics, we were struggling with the cumbersome multistaged and highly unsatisfactory antethoracic esophagoplasties (Fig. 101). In marked contrast, today we can resect the esophagus at any level and reestablish the continuity of the gastrointestinal tract. The technical aspects of and safety factors for these procedures are now so well established that it is feasible to do even palliative resections as easily as at any other level of the gastrointestinal tract. Furthermore, considerably greater varieties of lesions of the esophagus and stomach are now being treated surgically with constantly improving operative technic and results.

Since most of the important surgical diseases of the esophagus are, to some extent, obstructing in nature, they present a common symptomatology of varying degrees and combinations of dysphagia, regurgitation and substernal pain and distress. These symptoms are of great significance since they are frequently caused by such important clinical diseases as diverticulum, cardiospasm, mega-esophagus, esophagitis, stricture, benign tumors and carcinoma. Such patients, therefore, deserve careful study including fluoroscopy and roentgenograms and further investigation by esophagoscopy if indicated, since most of these lesions are now amenable to safe surgery, and good results are obtained if the diagnosis has been established at the proper stage of the disease.

ESOPHAGITIS ASSOCIATED WITH DUODENAL ULCER

Esophagitis of varying degrees is not uncommonly associated with duodenal ulcer and the ulcer diathesis. This esophagitis may be only mild and produce minimal symptoms. We have seen a number of patients, however, in whom the esophagitis has been so severe that there have been marked dysphagia and an acute stricture of the lower esophagus (Fig. 102). Treatment consists of rigid ulcer management and careful esophageal dilatation under the protection of antibiotics. We have not seen this particular type of esophagitis and acute stricture

Revision of article to be published in Postgraduate Medicine, 1951.

progress to the permanent cicatricial type which requires resection except in those instances in which it is directly associated with cardial lesions and cardiospasm.

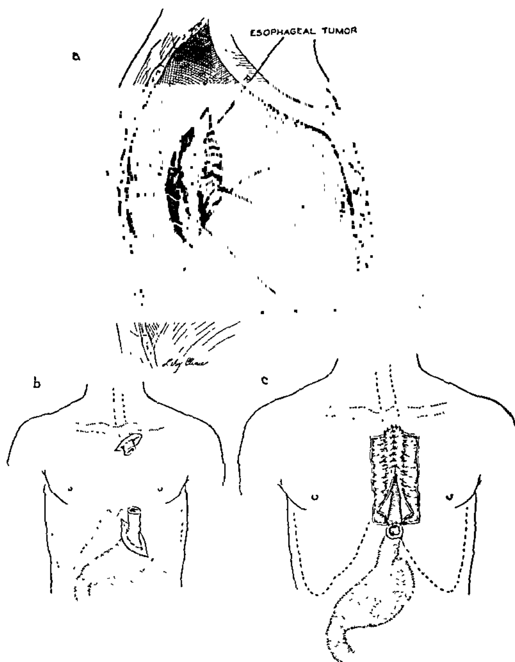


Fig. 101. Multistaged antethoracic esophagoplasty used before the advent of antibiotics.

MEDIASTINITIS FOLLOWING INSTRUMENTATION

At this point I wish to introduce a word of caution regarding the procedures requiring esophageal manipulation, such as esophagoscopy and esophageal dilatations, since a serious mediastinitis can develop at any time associated with these procedures. Actual rupture of the esophagus is not necessary to produce this serious complication and merely fissuring of the edematous friable mucosa may lead to a fulminating mediastinitis. Before the days of antibiotics patients who

developed this serious complication could be saved only if the diagnosis were made within a few hours and a posterior mediastinotomy (Fig. 103) carried out at once. The diagnosis was made on the basis of the patient's substernal, epigastric or back pain associated with a marked and immediate systemic reaction. The present feeling, however, is that if these patients are properly treated with antibiotics prophylactically through the period of the manipulation, and if at the first signs of any symptoms, massive doses of antibiotics are administered, mediastinal drainage will not be necessary unless there is gross perforation of the esophagus which should be recognized at the time of the procedure.



Fig 102. Stricture of the esophagus associated with duodenal ulcer.

CAUSTIC STRICTURE

Another type of stricture of the esophagus is caused by the ingestion of caustic chemicals (Fig. 104, *a*). This type invariably goes through an acute phase with various complications and terminates in a true cicatricial stricture of the esophagus involving a considerable length of this structure. Dilatations rarely are of any value in this situation. Usually these patients require a gastrostomy to carry them through the acute phase and eventually a resection of the destroyed esophagus and an esophagogastric anastomosis within the thorax (Fig. 104, *b*).

TRAUMATIC STRICTURE

In this day of great mechanical hazards I wish very briefly to discuss esophageal injuries associated with either penetrating or nonpenetrating crushing injuries to the thorax. Perforation of the esophagus or the establishment of a traumatic esophagotracheal fistula may definitely result from any injury of this type. Esophagotracheal fistulas of the spontaneous type almost always are caused by carcinoma (Fig. 105) which at this stage is inoperable. Benign esophagotracheal fistulas, however, may be due to trauma or to ingestion of a foreign body, with laceration of the esophagus and the membranous portion of the trachea. During the acute stage, nothing is given by mouth; the patients are fed by gastrostomy,

Fig. 103. Posterior mediastinotomy.



Fig. 104. *a*, Chemical stricture of the esophagus. *b*, Resection of the destroyed esophagus and esophagogastric anastomosis high in the thorax.

and the infection is treated by administration of massive doses of antibiotics. Eventually these fistulas have to be closed. Very satisfactory exposure of this area can be obtained by the transpleural approach through the right thorax, ligating and sectioning the azygos major vein (Fig. 106). The fistula is exposed and excised and the esophagus and membranous portion of the trachea are care-



Fig. 105. Esophagotracheal fistula due to carcinoma primary in the esophagus.

fully closed under direct vision. With adequate use of antibiotics, primary healing without residual infection can be expected.

DIVERTICULA

Diverticula are common obstructing lesions of the esophagus, are of two distinct types, and occur usually at three different levels in the esophagus. The commonest is the pulsion diverticulum which arises in the cricopharyngeal region and extends down into the superior mediastinum (Fig. 107). In this type of diverticulum the dependent sac reaches such a size that when filled with food the weight is sufficient to angulate the esophagus at the neck of the diverticulum so that the lumen of the esophagus immediately below this point is completely obstructed. Because of the great hazard of mediastinitis before the advent of penicillin, patients with esophagopharyngeal pulsion diverticula were best operated on by a two-stage procedure. At the first stage the sac was freed, elevated and usually sutured to the sternohyoid muscle (Fig. 108), which overcame the esophageal obstruction, allowed free drainage from the sac and sealed off the fascial planes leading from the cervical region into the mediastinum. At the sec-

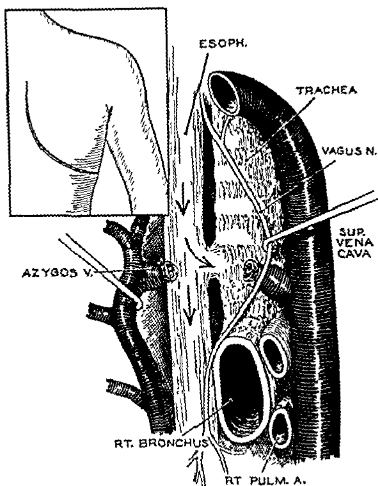


Fig. 106. Transpleural exposure of esophagotracheal fistula through the right thorax. (Reprinted from Journal of Thoracic Surgery, 1946.)



Fig. 107 Pulsion diverticulum of the cervical esophagus.

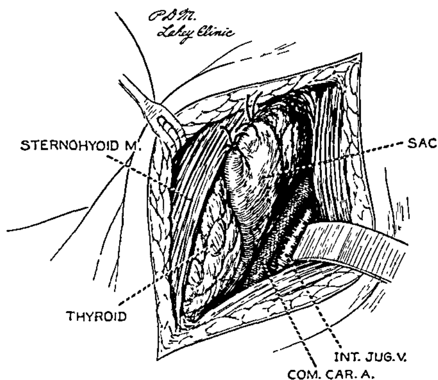


Fig. 108. First stage elevation of pulsion diverticulum of cervical esophagus.

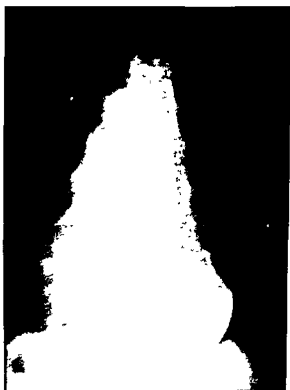


Fig 109. Pulsion diverticulum of the lower thoracic esophagus.

ond stage, about a week after the first stage, actual resection of the sac was carried out.

Another type of true pulsion diverticulum occurs in the lower third of the esophagus, usually filling the mediastinum behind the heart (Fig. 109) and frequently causing symptoms of distress and pain simulating angina pectoris. Obstructive symptoms also eventually develop in patients with these diverticula and result in malnutrition of the patient. Here again, before the days of anti-

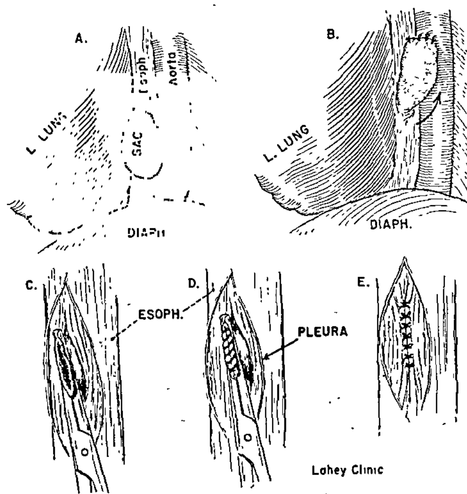


Fig. 110. *A* and *B*, Diverticulopexy. *C*, *D* and *E*, Resection of the pulsion diverticulum of the lower thoracic esophagus.

biotics, we had a number of cases of large pulsion diverticula of the lower thoracic esophagus in which the sac was freed up and the apex sutured as high as possible to the mediastinal pleura. This diverticulopexy without subsequent resection (Fig. 110, *A* and *B*) gave very satisfactory results and there was no danger of mediastinal or pleural contamination. Since antibiotics have become available, however, these large pulsion diverticula of the lower third of the esophagus have been resected in one stage (Fig. 110, *C*, *D* and *E*). They must be carefully mobilized, preserving the muscularis fibers encircling the neck of the diverticulum. It is most important to avoid too much traction on the sac in order that too much mucosa is not removed from the neck of the diverticulum, thereby narrowing the lumen of the esophagus, causing a stricture at this point. It is most



Fig. 111. Surgical specimen of large diverticulum of lower third of the esophagus and associated cardial stricture.

Fig. 112. Traction diverticulum of midthoracic esophagus.

important that the surgeon be aware of the fact that in at least half of these cases of large obstructing pulsion diverticula involving the lower third of the esophagus there is an associated intractable cardiospasm with advanced cicatricial stricturing of the cardia as well. If this condition is not recognized and the diverticulum alone treated, the obstruction will not be relieved. It will be necessary to do a secondary operation and resect the cardia. Therefore, in patients who have both a large pulsion diverticulum and a cardial stricture, it is best to resect the cardia and the lower third of the esophagus (Fig. 111) to above the neck of the diverticulum and to do an esophagogastric anastomosis at this level.

The other type of diverticulum is the *traction diverticulum at the level of* the hilar structures of the lung (Fig. 112). These rarely reach sufficient size to cause obstructive symptoms. The inflammatory process usually arising in hilar nodes, which during the healing and retraction stage produces the outpocketing and diverticulum, occasionally involves the entire circumference of the esoghagus, with the resulting progressing obstruction caused by stricturing of the esophagus rather than by the diverticulum. In such a case a high transpleural resection of the esophagus with a high esophagogastric anastomosis above the level of the arch of the aorta is necessary.

TUMORS

Probably the commonest obstructing lesion of the esophagus is tumor. Such tumors may be the result of extension and secondary to a primary lesion in some



Fig. 113. *a*, Esophageal polyp. *b*, Leiomyoma of the upper thoracic esophagus.

other organ closely related to the esophagus, such as the bronchus, or they may be primary in the esophagus itself. The commonest form of primary tumor of the esophagus is carcinoma. Occasionally benign tumors are seen, and because of their rarity and their amenability to permanent cure, they *are of considerable* interest. Benign tumors may be esophagenic cysts, polyps, fibromas and leiomyomas (Fig. 113, *a* and *b*). They occur at practically every level in the esophagus and rarely require esophageal resection. The esophagus at the level of the tumor

is carefully mobilized (Fig. 114) and the tumor resected under direct vision. Fibromas and leiomyomas are intramural and encapsulated and can be carefully

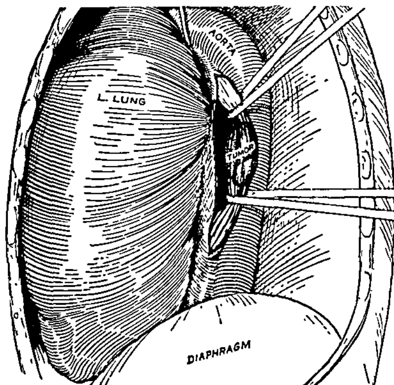


Fig 114. Surgical exposure of a benign tumor of the midthoracic esophagus.



Fig. 115 *a*, Carcinoma of the esophagus in the superior thoracic strait. *b*, Cervical esophagogastric anastomosis.

dissected out of the muscular wall of the esophagus without extensive damage to the muscularis and usually without opening the mucosal layer. The muscularis is then carefully reconstructed with fine interrupted silk. Some of these tumors

are pedunculated or mainly intraluminar, and the base can be excised, thereby opening the mucosa. All layers must be carefully reapproximated with interrupted silk.

The commonest obstructing tumor is carcinoma which occurs at all levels, but the surgical approach, surgical management and technical details vary considerably according to the level involved. If the diagnosis is made at an operable stage, carcinoma of the esophagus can be safely resected at any level, including the superior thoracic strait (Figs. 115, *a* and 116), and the continuity of the



Fig 116. Surgical specimen of carcinoma of the esophagus shown in Figure 115, a.

intestinal tract re-established by displacing the stomach through the diaphragm into the thorax and even into the cervical region (Fig. 115, *b*) for esophagogastric anastomosis. We believe that esophagoscopy should be done in all cases for biopsy and grading, and any evidence of inoperability determined by direct vision. All patients with the higher lesions should also have a bronchoscopy to rule out direct invasion of the bronchus or trachea which would make the tumor definitely inoperable.

Carcinoma of the cervical esophagus can be resected and the continuity of the intestinal tract re-established by one of two methods. In rare instances the lesion is of such short length that it is possible to resect it adequately within the limits of the cervical exposure and to re-establish continuity by the utilization of a skin tube (Fig. 117) from the anterior aspect of the neck. Most lesions, however, are not suitable for this procedure. Furthermore, carcinoma of the esophagus arises in the superior thoracic strait more commonly than in the cervical portion of the

esophagus, and total esophagectomy and a pharyngogastric anastomosis in the neck must be done.

In general, all of the lesions involving the upper thoracic esophagus and those in the superior thoracic strait are of considerably greater seriousness than those

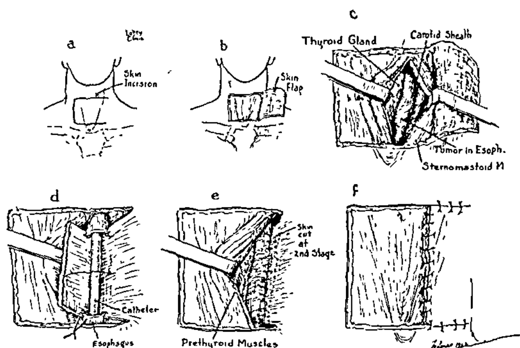


Fig 117. Resection of cervical esophagus and re-establishment of continuity by the use of a skin tube from the anterior aspect of the neck.

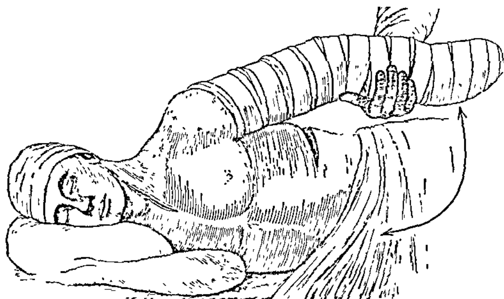


Fig 118. Position and draping for resection of the cervicothoracic esophagus.

at lower levels because of the magnitude of the procedure and, even more important, because of the extreme disturbance of cardiopulmonary function associated with these procedures. We no longer fear the complications of infection or leakage from the anastomosis but do see serious problems associated with the extensive disturbance of the cardiac function and greatly reduced pulmonary function

In all these high resections the possibility of right-sided cardiac failure during the immediate postoperative period must be kept in mind since it is impossible to estimate the cardiac reserve of these elderly patients and because the entire mediastinum necessarily must be dissected, with considerable manipulation of the arch of the aorta and the base of the heart, disturbance of the innervation of the heart, the complete displacement of the stomach into the chest, the paralyzed diaphragm

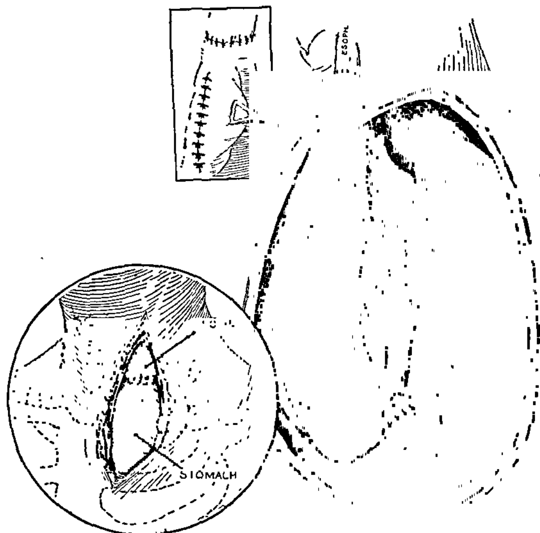


Fig 119 Fig. 120

Fig 119. Excision of the inner end of the left clavicle and first rib and pharyngeal gastric anastomosis in neck; cervical exposure.

Fig. 120. Sagittal section (see Fig. 119) showing transthoracic displacement of stomach into the neck.

and frequently the necessity of opening both thoraces at the same time in order to remove these high lesions. When carcinomas are situated at these levels we now digitalize the patients preoperatively, and we believe that this is the one indication for leaving a tube in the stomach for some days after the procedure to prevent any dilatation of the stomach in this particular position.

In carcinomas of the superior thoracic strait and low cervical region, the patients are placed on the operating table on their right side, left side up, in the usual chest position. The left arm is wrapped sterilely and the neck is included in the draping of the sterile field (Fig. 118). The arm is then displaced posteriorly

and the lower left neck is opened through a low cervical incision to determine the operability and to free this portion of the esophagus down into the superior mediastinum as far as possible. If the lesion has not extended to the carotid sheath and cervical nodes, or to other mediastinal structures, such as the membranous portion of the trachea, and can be freed up satisfactorily from this approach, the thorax is opened by a posterior lateral incision, resecting the sixth rib and cutting the fifth and seventh ribs close to the transverse processes. The mediastinum is opened above the arch of the aorta and the involved esophagus at this level mobilized and freed up to the level of dissection from above. With the lesion completely mobilized above and below, the remainder of the esophagus is freed

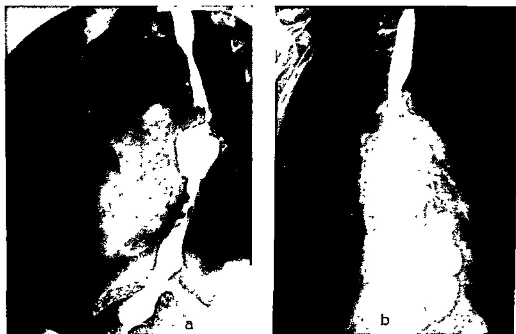


Fig 121. *a*, Carcinoma of the upper thoracic esophagus. *b*, Postoperative roentgenogram of esophagogastric anastomosis after removal of carcinoma shown in *a*.

up from mediastinum, the diaphragm is opened widely, the gastrosplenic and gastrocolic mesenteries are sectioned, the short gastric vessels are divided and the greater curvature of the stomach mobilized well down toward the antrum and pylorus, preserving the right gastro-epiploic artery along this curvature. The cardia of the stomach is mobilized and the gastrohepatic mesentery, including the left gastric artery, is secured and divided down to the antral region. The esophagus is transected immediately above the cardia and the cardia closed. The inner end of the left clavicle and the first rib are then resected through the cervical incision (Figs. 119 and 120) and the fully mobilized stomach passed transthoracically into the neck for anastomosis of the upper cervical esophagus or the pharynx to the top of the fundus. The detail of such an anastomosis is the same at any level, that is, a two-layer anastomosis of carefully placed interrupted silk sutures.

For lesions in the upper thoracic portion of the esophagus at the level of the arch of the aorta and the hilar structures of the lung (Fig. 121, *a*), a similar transthoracic approach is carried out. The mediastinal pleura is opened below the arch of the aorta, the esophagus distal to the lesion is mobilized and retracted

out of the mediastinum and the dissection carried upward (under direct vision) to free the lesion from the hilar structures and from the arch of the aorta. It may be necessary to section the upper intercostal vessels and turn the arch inward in order to complete this important dissection from the posterior aspect of the arch of the aorta under direct vision. In addition, at these high levels, it is often necessary because of direct invasion of the opposite pleura to open the contralateral thoracic cavity during the mobilization of the carcinoma. For this reason one cannot possibly overstress the importance of the anesthesia and the manage-

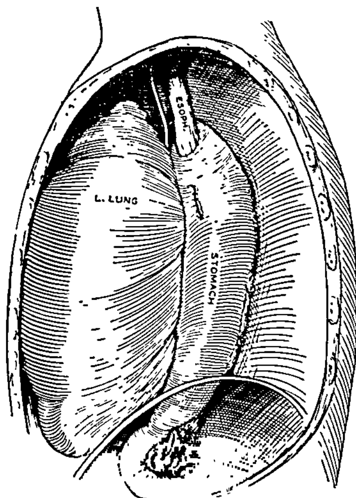


Fig. 122. Esophagogastric anatomosis superior and anterior to the arch of the aorta.

ment of these complex physiologic problems throughout this serious procedure. When the lesion has been entirely freed, the remainder of the esophagus must then be carefully mobilized, the diaphragm opened, the stomach mobilized as previously described, the esophagus transected at the cardia, the cardia closed, the lower transected end of the esophagus tied off with a heavy braid of silk and the thumb from a rubber glove tied firmly over the end. The esophagus and lesion are then carefully displaced upward from behind the arch of the aorta, traction maintained on the esophagus until the posterior rows of the anastomosis are completed, and the anastomosis made above and anterior to the level of the arch of the aorta (Figs. 121, *b*, and 122). Again I wish to stress that in these higher resections there is a marked physiologic disturbance which is of great significance

in the postoperative management of these cases. The stomach is almost totally displaced into the thorax, the stomach itself is extensively denervated by high vagotomy, there is marked reduction and disturbance of its blood supply, and it *is, therefore, prone to dilatation as it lies across the pericardium. If dilatation in* this particular position is allowed to take place, severe cardiorespiratory disturbance will result which may be so profound as to cause the death of the patient. Therefore, at this level a Levin tube which is placed down to the obstructing lesion before operation is passed through the anastomosis to the level of about

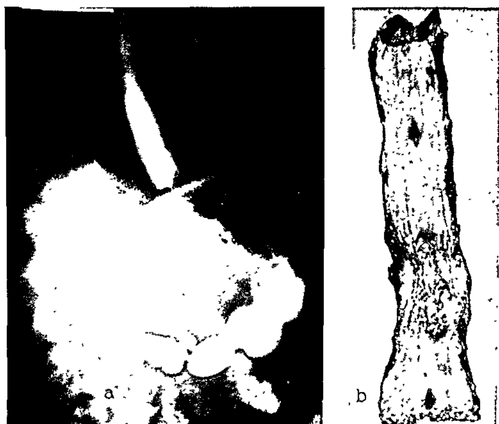


FIG. 123. *a*, Carcinoma of the lower end of the esophagus. *b*, Surgical specimen of *a*.

the mid stomach opposite the pericardium at the time the posterior rows of the anastomosis are completed. This tube is kept on suction for three or four days following the operation to avoid any dilatation. Contrary to past teachings, we have not seen any complications arise from such a tube lying across the line of anastomosis.

Lesions of the lower third of the esophagus (Fig. 123, *a*) and cardia are approached through a posterolateral incision, removing the seventh or eighth rib and cutting the rib immediately above and below close to the transverse processes. The esophagus and the lesion are mobilized from the mediastinum under direct vision, the diaphragm opened and as much of the stomach as necessary mobilized to allow anastomosis above the resected level without tension (Figs. 123, *b*, and 124). The true cardial lesions, however, require considerably greater resection of the stomach, especially along the lesser curvature, and frequently may require splenectomy (Fig. 125) as well, in order to resect extensions into the gastrosplenic mesentery. The stomach is mobilized as much as is neces-

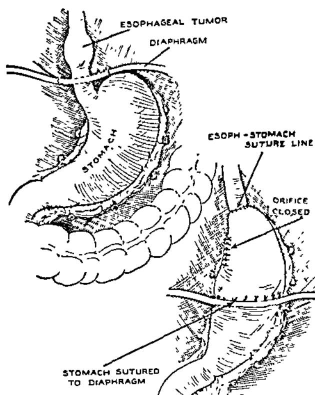


Fig. 124. Resection of the lower third of the esophagus.



Fig. 125. Surgical specimen, carcinoma of the cardia of the stomach and spleen.

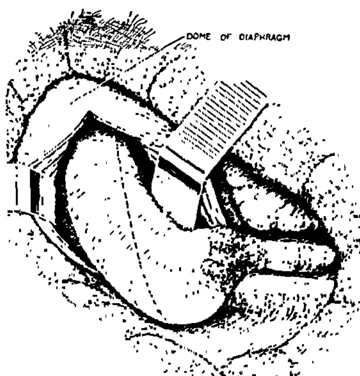


Fig. 126. Exposure and mobilization of the cardia and lower esophagus. Dotted line shows line of resection.

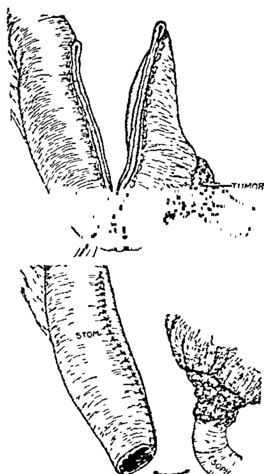


Fig 127. Technic of transection of the stomach, closure and formation of the gastric stoma.

sary, a von Petz clamp is placed obliquely across the stomach, taking a greater length of the lesser curvature, and this oblique incision closed up to the approximate size of the esophagus above the lesion (Figs. 126, 127 and 128). In these lower lesions the esophagus often is not dilated at all and is frequently even contracted to a smaller caliber than normal, and in this type of anastomosis a

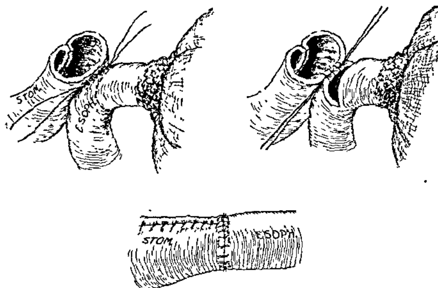


Fig. 128. Technic of the esophagogastric anastomosis.

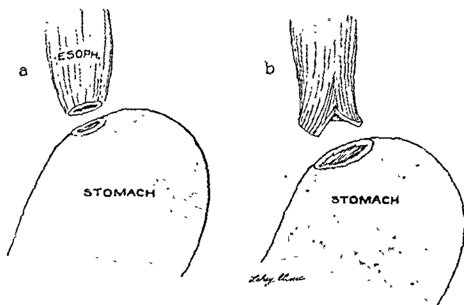


Fig. 129. Method of enlarging the esophageal lumen to increase the size of the esophagogastric stoma.

stricture and poor function may result. Under these conditions it is best to increase the size of the anastomosis by enlarging the end of the esophagus by cutting the lateral wall upward for a short distance (Fig. 129). This is superior to the oblique incision across the end of esophagus since the circulation of the tip of the obliquely transected esophagus is poor.

In all cases of esophagogastric anastomosis in which the stomach is displaced into the thorax, the diaphragm must be permanently paralyzed by resecting a

length of phrenic nerve as it crosses the pericardium. The diaphragm is closed, leaving an adequate opening for the stomach at whatever level it passes through this structure. In all instances an intercostal catheter is left within the thorax for suction to aid rapid re-expansion of the lung. We have not found it necessary to leave a Levin tube in the stomach in the lower esophageal resection.

CARDIOSPASM

Finally we come to a very interesting group of obstructing lesions which have been rather vaguely classified in the past under the heading of cardiospasm. As larger numbers of these patients were considered for surgical treatment, however, only a certain number of these proved to have true cardiospasm and it became



Fig. 130. Achalasia of the esophagus due to cardiospasm.

obvious that there are other rather complex conditions of a different nature which were formerly called cardiospasm. It became apparent that each case must be very carefully studied and evaluated before carrying out surgical treatment. We now prefer to classify these lesions under the general term of achalasia of the esophagus (Fig. 130), which includes cardiospasm, mega-esophagus and hiatus hernia associated with cardiospasm, esophagitis and at times ulceration and true cicatricial stricturing of the cardia. The exact pathologic changes at this level, of course, must be very carefully evaluated by roentgenography and esophagoscopy in order to determine the procedure of choice and to obtain the best permanent results. True cardiospasm without cicatricial changes and stricture, as a rule, does not seriously interfere with the nutrition of the patient. Many of these patients may have had the condition for many years, but they have been able to adjust their eating so that enough food gets through their cardia to maintain nourishment in spite of the development of considerable dilatation of the esophagus.

These patients are most unhappy and have considerable distress, however, and eventually in many of the cases the contents begin to spill over into their lungs and chronic pneumonitis develops. Most of these cases can be handled satisfactorily by dilatations, and only those patients with intractable lesions require sur-

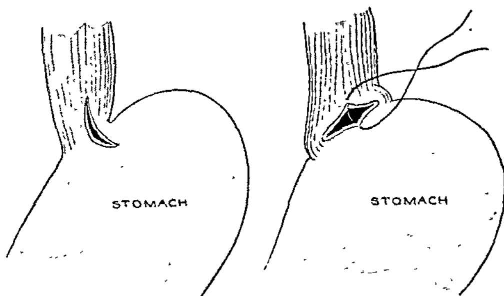


Fig. 131. Cardioplasty for cardiospasm.



Fig. 132. Mega-esophagus, *a*, plain film; *b*, barium film.

gical intervention. If the condition proves to be true cardiospasm, a simple cardioplasty or esophagocardial myotomy can be carried out and good results obtained (Fig. 131). If there is an associated esophagitis and cicatricial contracture resection will be required.

Mega-esophagus. There is still another group of cases which fall into a category similar to megacolon, in which there is congenital absence of Auerbach's plexus at the lower end of the esophagus which therefore acts as an obstructing

nonfunctioning segment. A tremendous dilatation, a true mega-esophagus, develops. The treatment of choice in these cases is careful preparation by prolonged decompression and aspiration of the esophagus, and eventually extensive resection, including the nonfunctioning segment at the lower end. In some of these patients such a tremendous dilatation (Fig. 132, *a* and *b*) and so much associated pneumonitis develop that it will be necessary to put the esophagus totally at rest by gastrostomy and to improve the patient's general condition and nutrition for some months before they undergo surgical resection. Hiatal hernias with associated esophagitis or ulceration or stricture are usually related to an ulcer diathesis and this aspect of these problems must be carefully evaluated and controlled. The entire group of lesions of this type is indeed much more complex than it appeared to be in the past and these patients will require considerably more study and individualization as to treatment in order to obtain satisfactory results.

In summary, I have presented rather briefly the salient features of the surgical management of obstructing lesions of the esophagus and the cardia of the stomach. It is quite apparent from this that the surgery of the esophagus and upper gastrointestinal tract has become a very complex field, but many of these procedures are now highly standardized operations, giving excellent results.

THE TECHNIC OF TOTAL PNEUMONECTOMY

DAVID P. BOYD

I. TECHNICAL STEPS IN THE STANDARD OPERATION

Great strides have been taken in pulmonary surgery since the early successes of Graham, Rienhoff and Crafoord and their early descriptions of the technic of pneumonectomy. The studies of Churchill, Blades[9] and others have opened new chapters in surgical anatomy and extended the technic of resection of the lung to include lobes and segments with increasing precision.

No attempt will be made to discuss the specific problems which various lesions present. Rather a broad approach will be taken to the problems of lung resection as a whole. Whether for cancer, abscess, bronchiectasis or even tuberculosis, the technical problems are essentially the same. Indeed, frequently more than one of these lesions are present in the same lung.

ANESTHESIA

In the thoracic team the anesthetist holds an important place. Without a skilled anesthetist, these operations are more difficult and dangerous. It is rare that pneumonectomy is an elective operation which can be postponed indefinitely or one in which the condition of the patient can be greatly improved. Many patients requiring this procedure have coronary sclerosis and emphysema. In addition to this, many have a low vital capacity and diminished cardiorespiratory reserve. Furthermore, many of these patients who are considered for total pneumonectomy because of low grade epidermoid carcinomas of the bronchus have not lost weight and often have an undesirable degree of obesity. The presence of large amounts of mediastinal and pericardial fat is just as disturbing to the thoracic surgeon as is extensive fat infiltration of the mesentery and abdominal viscera to the abdominal surgeon. When all of these things are considered it is obvious that the requirements for successful anesthesia in many of these cases are of the utmost importance. It is particularly important to avoid anoxemia in these operations. It is for this reason that we are reluctant to use pentothal sodium at any time during these operations. No one can foretell when pentothal sodium is used which patient will have laryngospasm and which will not. Laryngospasm brings about anoxemia and even if it is temporary, this anoxemia may be sufficient to cause irreparable damage in a patient with a low respiratory reserve.

Perhaps the next consideration of importance is the maintenance of an airway free from secretions. This is of the greatest importance in patients with lung abscess and in the occasional resection which is done for tuberculosis. Provision for positive pressure is essential. It is not likely that in operations upon the lung

Revision of article published in Surgical Clinics of North America, 29·717–726 (June) 1949.

the opposite pleural cavity will be entered but it is of value to aerate the lungs at regular intervals during the procedure.

Finally, the anesthetist is responsible for supportive treatment before, during and after the operation. He is justified in rejecting a candidate who can be further prepared to withstand a serious operative procedure. He supervises the administration of blood and other fluids during the operation and prescribes until the patient is fully conscious. In addition to various stimulants and supportive agents, intravenous procaine and digitalis for the management of cardiac irregularities are at the disposal of the anesthetic team during the operation.

It is realized from these remarks that the function of the anesthetist is a critical one. While many pneumonectomies and other intrathoracic operations can be done with very little disturbance to the patient's general state and without the aid of special anesthesia and anesthetists, nevertheless one never can predict in which case difficulties will arise for which one must be prepared if disaster is to be avoided.

APPROACH

In general, two approaches are advocated for the performance of pneumonectomy, the posterolateral approach and the anterior intercostal approach. The early cases of Graham and Crafoord were done through a posterolateral incision, and this approach has become almost standard for this type of work. Rienhoff, however, has continued to advise an anterior intercostal approach. More recently, Overholt has advocated a modification of the posterolateral approach in which the patient is in the prone position.

The anterior approach has many advantages. The chief advantage is the dorsal recumbent position of the patient, which is the most favorable for a patient with low cardiorespiratory reserve. It has the further advantage of reducing the time required to open and to close the chest, a consideration of some importance in prolonged cases. Unlike the other modes of entry, there is little or no blood loss with this approach. In addition to these considerations, the hilum of the lung and, in particular, the pulmonary artery are readily accessible from the anterior approach. Inasmuch as the artery is usually the first structure to be dealt with, this is a consideration of importance.

The disadvantages of the anterior approach are that, like all intercostal incisions, it is difficult to close and if the lung is firmly fixed to the chest wall, the technical difficulties of freeing it become almost insurmountable and much of the dissection has to be done almost blindly, particularly at the posterior apex and in the costophrenic angles. In addition to this, if the lung is solid there may not be enough working space to deal with peripheral attachments and even with the hilar dissection The incision is excellent for the simple, easy case and might be recommended for cases of pneumonectomy for adenoma and in which it may be assumed that no great technical difficulties will be encountered. If the history suggests that the case might be an uncomplicated one, this incision should be seriously considered. If there is the slightest doubt, however, or if the study suggests that fixation will be found in any part of the lung, then perhaps another approach should be employed.

The posterolateral incision is probably the most universally popular for lung

resection. By resecting one rib in its entirety and dividing the rib above and below, wide exposure of the thorax can be obtained. This is of paramount importance in difficult cases inasmuch as it may be essential to be able to introduce both hands into the thoracic cavity. If total pneumonectomy is contemplated, the fifth or sixth rib should be resected from the costal cartilage almost to the transverse process. If ribs are resected too low in the thoracic wall, it will be difficult to deal safely with apical adhesions. Furthermore, dissection of the pulmonary artery, which is the most critical part of the operation, may be made unnecessarily difficult. Increased exposure may be obtained by dividing the rib above and the rib below, preferably with resection of a small portion of these ribs. Of all the devices which have been suggested for reducing the postoperative intercostal pain, ligation of the bundle after its division is the most gratifying. A patient seldom complains of pain in the chest wall after this procedure has been employed. Through this approach all parts of the hilum are equally accessible. The lung can be moved freely anteriorly and posteriorly and when all is considered it is probably the most universally useful. It has the disadvantage, however, that the lung and mediastinum tend to gravitate away and the surgeon often finds himself working at the tips of his instruments. It also has the serious disadvantage of placing a patient who may have a low respiratory reserve on his good side for several hours. The anatomy, however, is presented without distortion in its classical relationship.

The modification of the posterior approach which is used by Overholt is advantageous from several standpoints. The prone position of the patient is said not to introduce any additional anesthetic problems. In fact, it is believed by some that it favors respiratory exchange and makes aspiration of secretions by the anesthetist simpler. In addition, it is considered by some to lessen the danger of aspiration and spread to the uninvolved side. Another advantage in this exposure is that the hilum does not tend to gravitate away; it actually appears to be a little closer to one's instruments. It is very simple to secure the bronchus early in the dissection, if this is desirable, as in a case of abscess. Another possible advantage is that the operator can sit down from time to time. I have used this incision on numerous occasions with great satisfaction. The only serious disadvantage which I have noted is that it may be extremely difficult to deal with the superior pulmonary vein. The latter is anterior in the hilum and it is necessary to lift the lung up against gravity to secure it. If dissection in this area is particularly difficult, as it occasionally is, this approach makes it more so. All things considered, I believe that this is often the position of choice for pneumonectomy for serious lung abscess.

MOBILIZATION OF THE LUNG

No matter what the indication for pneumonectomy, the lung may be solidly bound to the parietal pleura. In lung abscess, it always is; in bronchiectasis and carcinoma, it frequently is. It is essential to proceed until operability is determined. The synechia between the visceral and parietal pleura may be filmy, thin and avascular or it may be extremely dense and vascular. The diaphragm and pericardium are frequently involved in this fixation, as are the great vessels in the superior mediastinum. With experience, one soon learns that in these vascular

adhesions, careful, slow, tedious, mostly sharp, dissection is required. No finger or gauze dissection should be employed if excessive blood loss and shock are to be avoided. Dissection as far away from the parietal pleura as possible will give the best results. Small tears in the lungs may be easily repaired with hemostatic sutures but bleeding points which are retracted into the thoracic wall are extremely difficult to secure. As soon as the chest wall is opened one can estimate the situation so as to inform the anesthetist that there may be excessive blood loss. Thus, he will be prepared to administer supportive therapy.

THE LARGE SOLID LUNG

Of the numerous impediments which may be encountered in attempting to remove the lung, none is more difficult to deal with than a large, solid, uncollapsible organ. It is especially important in such a situation to have sufficiently wide exposure to allow both hands to move freely within the thorax. This may be secured by dividing additional ribs posterior to the angle. In one case, in which the lung weighed 1500 gm., even this would not permit exposure of the hilar structures. The fifth rib had been resected and the sixth and seventh ribs divided at their posterior articulations. To secure the required exposure the sixth and seventh ribs were severed close to the sternum and turned down as a flap. This procedure gave adequate working space. In another case of solid lung in a poor risk patient with low respiratory reserve, manipulation of the organ caused asystole and hypotension. When the dissection was interrupted and the lung lifted away from the heart, pressure was restored and regular rhythm and systole resumed. By a series of intermittent and rapid sessions of this type, the lung was finally removed.

HILAR DISSECTION

It is well to have a definite and regular plan for dealing with the hilar structures, although expediency may dictate variations from time to time. When all adhesions between the hilum, pericardium and parietes have been freed, the mediastinal pleura is opened as high up on the lung side as possible in order to preserve pleural flaps for closure. In most cases in which radical resection is undertaken, and especially on the left side, it is difficult to obtain enough pleura to close the mediastinum.

After the pleura has been incised all the way around the hilum, the decision regarding resectability must be reached. The presence of paratracheal nodes or nodes elsewhere in the mediastinum too inaccessible to reach, may be determined by palpation. The bronchoscopist's remarks will be borne in mind regarding the amount of available main stem bronchus above the visible tumor. While the pulmonary artery is the first logical structure to attack, I have made it a practice first to investigate both the inferior and the superior pulmonary veins to determine whether there is intravenous or perivenous extension of the tumor. If this is not done the surgeon may find that he has cut across tumor tissue in amputating the lung. This venous involvement may extend into the auricle itself. Dissection of the artery frequently is easy, especially in cases of suppurative disease, tuberculosis, or peripheral neoplasm. The superior pulmonary vein lies antero-inferior to the pulmonary artery and the bronchus and bronchial arteries.

postero-inferior, and often simple pledget dissection under direct vision will free enough of the main trunk to permit double proximal and single distal ligation. With the lung on the stretch toward the parietes, the first ligature of number 12 silk is placed on the artery as high in the mediastinum as possible. The anesthetist should be advised as this first tie is placed and the effect on the patient noted before the knot is set. No snaps or other traction device should be applied to this ligature. The next tie is placed as far out on the lung as possible, preferably as a transfixion ligature. Simple ligatures tend to slip off and cause troublesome back bleeding. Often in order to have a satisfactory proximal stump these distal liga-

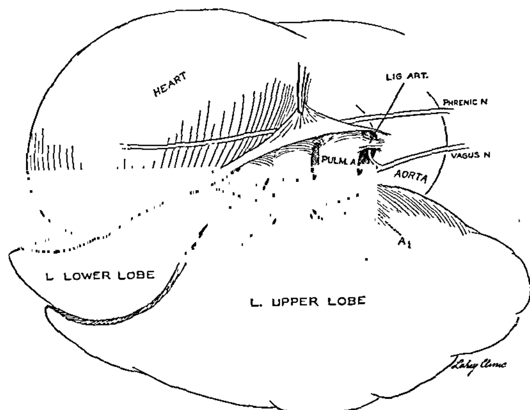


Fig 133. Diagrammatic representation of anterior aspect of hilum. Note main pulmonary artery dividing into apical segmental (A_1), anterior segmental (A_2) and lower lobe vessels. Posterior apical segmental artery (A_3) is obscured by A_1 and A_2. The artery to the lingula (A_4 and A_5) lies deeper in the fissure. The tributaries of the superior pulmonary vein correspond to the same arteries; the lowermost one shown here is the common vein from the segments of the lingula (V_4 and V_5).

tures must be applied to the primary divisions of the artery. A third ligature, also a transfixion, is placed close to the first and securely tied. The vessel is then divided. An important point in technic, perhaps more applicable to the smaller vessels and closer quarters encountered in partial lung resections, is that one should always cut a ligated vessel over a right angle clamp with the jaws partly open. This step may avoid injury to deeper vessels not yet secured. All fascia and lymph nodes should be removed to obtain a clean arterial surface for a safe and sure ligation. This is a fundamental principle in dealing with large blood vessels. This is the ideal and simplest method for dealing with the pulmonary arteries. However, if the artery is unduly short, or if the hilum is foreshortened

by local disease, the branches must be used. Obviously, this is less consistent with radical excision but safety may take precedence. Furthermore, in long-standing inflammatory disease, considerable difficulty may be encountered in dissecting the vessels from the upper lobe. Nevertheless, painstaking dissection will always be rewarded by secure ligations even in the presence of the worst adhesions and adenopathy, provided malignant infiltration has not occurred.

Attention is now turned to the superior pulmonary vein. In most cases secure ligation of the trunk vessel may be obtained. However, the pericardial reflection

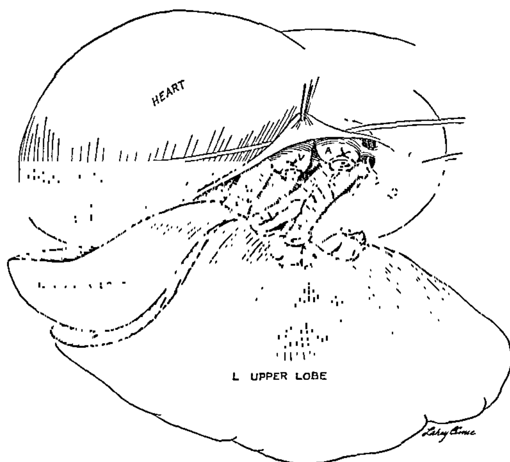


Fig. 134. The artery has been divided as a trunk, followed by division of the superior pulmonary vein; adequate stumps are shown; the ever-present cuff of pericardium on the vein is not shown. The bronchus and its artery are now ready for treatment as indicated in the text and shown in Figure 135.

often extends out onto the anterior surface of this vein and a dependable ligature cannot be applied without removing these extensions, and thereby opening the pericardium. This large vein, furthermore, is thin and may be densely adherent to the bronchus. It may merge into the inferior pulmonary vein in the diseased hilum and occasionally there may be but one large, common pulmonary vein. It is almost always possible to place a satisfactory ligature on the main trunk after which the branches from the lingula and from the remainder of the upper lobe are ligated and divided over a partially opened right-angle clamp, leaving a proximal stump of good length. In a deep chest, in any position except possibly the dorsal recumbent, this vein lies at the bottom of a deep cavity. With poor exposure and inadequate lighting, the stage is set for tragedy. The lung must be

lifted backward and outward. The operator must wait until the lights are so adjusted that visibility is unhampered and deliberate, precise handling is possible. If one of the great veins is inadvertently torn, it can usually be managed if exposure and lighting are adequate. A pledget of oxycel gauze should always be within easy reach of the surgeon. With this he can catch the vessel lightly between finger and thumb. With the situation thus temporarily controlled, the field can be sucked dry, lights adjusted, and if necessary, more ribs cut to allow both hands free motion within the thorax. A plan of attack can then deliberately be formulated. Usually, one of two technics is possible. With the left index

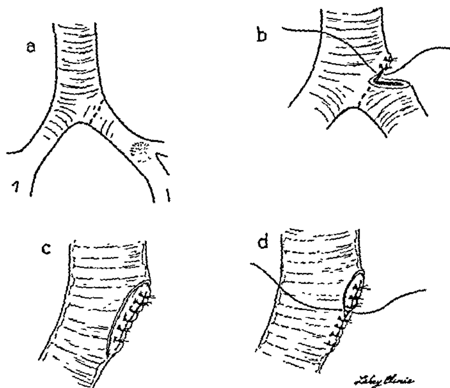


Fig. 135. This shows the method used at the Lahey Clinic for many years to close the bronchus. The second layer (*d*) is no longer considered essential, but the stump should be covered with pleura if possible.

finger under the vein which is slightly on the stretch, the thumb can be slowly removed from its anterior surface. If sufficient extrapericardial length remains, a number 12 silk suture can be placed precisely through the wall of the vein proximal to the perforation and tied by an assistant (Fig. 134). Another suture may be placed to occlude the remainder of the vein. Muscle or oxycel may be incorporated. If this procedure is not possible, the pericardium may be opened and the vein secured where it enters the atrium. This is not difficult if manipulation is unimpeded.

Before the inferior pulmonary vein is dealt with, the bronchus should be secured since the bronchial arteries are still carrying blood into the specimen. These are important vessels, especially in older patients, and are at times a surgical problem. We disagree with statements in the literature that they are not significant considerations in lung resections. On the contrary they are constant in their presence, but variable in number, and require precise technic of handling

to maintain a dry field during bronchial closure. An attempt is made to isolate these vessels and tie them with fine silk on a French needle about 1 mm. above the proposed line of transection of the bronchus.

Many technics are advocated for closure of the bronchus, an organ which, as Clagett pointed out, was specifically designed by nature to stay open at all times. Most surgeons believe that their special methods have given steadily improving results. The avoidance of ulceration and infection of the stump, which we owe to chemotherapy, is probably the important factor. A technic which avoids crushing clamps, necrotizing chemicals, and strangulating sutures is highly desirable. A simple anteroposterior closure of the end of the stump with interrupted fine silk sutures recommended by Dr. Herbert D. Adams is used at the Lahey Clinic (Fig. 135). Two sutures are placed at the extremes of the proposed line of section. The distal bronchus is occluded with a heavy tie to avoid further drainage from the specimen. The field is walled off, the suction apparatus made ready, and the bronchus is opened about 0.5 cm. The first suture of fine silk on a French needle is placed and tied. The bronchus is further transected to allow placement of the next suture which is also tied, and this procedure continued until the closure is completed. There should be minimal soiling and absolutely no intrabronchial aspiration of blood. Furthermore, there is very little change in the depth of anesthesia because the circuit is scarcely disturbed. Section is carried out as close to the carina as possible. This leaves the specimen hanging by the inferior pulmonary vein and ligament. Two ties are placed on this vessel close to the pericardium and the lung cut away, leaving a proximal stump of good length.

An attempt is then made to remove all lymph nodes from the mediastinum, which have not already been removed with the specimen, especially in the peritracheal area and under the carina. Finally, great care is taken to pleuralize the mediastinum, especially the bronchial stump. Despite every effort to preserve pleura it is not always possible to close the mediastinum, especially on the left side. As a rule, however, sufficient pleura is available to cover the bronchial stump.

II. A MORE RADICAL TOTAL PNEUMONECTOMY

While at times partial lung resections may of necessity be indicated in the treatment of carcinoma of the lung, it is generally agreed that the most radical operation possible will give the greatest chance of cure. It might even be said that the more favorable the lesion appears, the more radical one should try to be. Some of the extensions of the standard operation of pneumonectomy which are described herewith are obviously applicable only to certain specific circumstances. They should, however, be familiar to the surgeon in order that a patient with a large infiltrating, but slowly growing, lesion may not be rejected.

1. INVASION OF THE THORACIC WALL

Most peripheral lesions in the lung rapidly become fixed to the parietal pleura. When secondary infection is present or when the tumor has undergone necrosis, this is always so. Frequently the simple device of passing out of the intrapleural

Revision of article published in Surgical Clinics of North America, 31:823–826 (June) 1951.

into the extrapleural plane will suffice to free such a lesion. A good line of cleavage can readily be found in the endothoracic fascia if actual invasion has not occurred. If it has, block dissection of the pleura, ribs and intercostal muscles becomes necessary. Similarly, areas of sternum may be resected *en bloc* with the lung. An example of this is given in the following case report.

A man of 56 years had an explanatory operation through the right chest because of a dense shadow in the region of the middle and lower lobes of the right lung. A tumor was found involving these two lobes, but also densely adherent to the costal cartilages and the sternum, to the anterior aspects of the lower ribs and to the pericardium. The pathologist reported that this lesion was a low grade fibrosarcoma arising in the lung and resection was considered feasible. Along with the lung, the adherent pericardium and the entire block of thoracic cage, consisting of the edge of the sternum, three costal cartilages, three ribs and overlying muscles, were resected. At the anterior extremity of the defect, the pectoralis and other muscles were entirely gone and nothing but skin remained. Furthermore, this was itself inadequate and a "Z" flap was necessary to effect closure. The patient made a smooth convalescence and was made quite comfortable by the application of a stabilizing garment for his thorax. Inasmuch as all the tumor apparently was removed and the lesion was of relatively low grade malignancy, the radicalness of the attack appeared to be justified.

This extension of lung resection is straightforward and feasible and if due attention is paid to blood loss, it is well tolerated by the patient. The greatest problem may be in closing the chest wall afterward. As in the case reported, skin and sometimes one layer of muscle may be all that remain. Paradoxical respiration will be noted in the convalescence and this may be a serious problem. With the passing of time and the use of fitted garments, however, satisfactory adjustment will occur. We have had an occasional patient in whom the defects have been so extensive that the chest wall has not been stabilized sufficiently for comfort. In one such case it is contemplated to attempt to stabilize the chest with ribs derived from the bone bank. This may well prove to be the answer to this problem in the future.

II. FIXATION TO THE DIAPHRAGM

Large areas of the diaphragm along with the lung may be resected and the defect repaired satisfactorily. It is, of course, much more important to secure a good repair on the left than on the right side. If the defect will not close readily, the phrenic nerve should be divided. Occasionally, even after phrenicectomy, the defect cannot be closed. Two methods are available in these extreme cases. A plaque of fascia lata may be used, taken from the patient's thigh and sutured in place with fine silk. Alternatively, a lower rib thoracoplasty may be carried out just sufficient to allow the hiatus in the diaphragm to be closed without tension.

THE SUPERIOR MEDIASTINUM

The structures of the superior mediastinum cannot be sacrificed, and fixation in this area may, and frequently does, make resection impossible, especially on the right side. In more favorable cases, particularly carcinomas of the upper lobe, it would seem reasonable to begin at the apex of the chest medially and clean

the esophagus, trachea and great vessels from above downward. This dissection removes pleura, fascia, areolar tissue and lymphatic nodes as much *en bloc* as possible. The dissection proceeds from the apex to the hilum and includes an inch or so of the arch of the azygos vein. This technic is in accord with the principles of cancer surgery elsewhere, for example, in the mammary gland. In a similar fashion, the pleura and loose tissue from the diaphragm to the inferior pulmonary vein are taken, including the pulmonary ligament, thus exposing the inferior vena cava and the lower esophagus.

Careful dissection of the superior mediastinum would seem the more reasonable when it is recalled that many advanced pulmonary cancers present in the neck show at autopsy a chain of paratracheal lymph nodes running up to the jugular group. It may be remarked in passing that this maneuver may well result in bilateral pneumothorax and if this occurs a clamp or ligature should be placed on the bronchus as soon as possible. This will prevent the overexpanded lung from interfering with dissection, since the anesthetist must use positive pressure because of the air in the contralateral chest.

THE HILAR DISSECTION

The most trying part of a pneumonectomy from the technical standpoint is the hilar dissection, especially dissection of the pulmonary artery and the superior pulmonary vein. This is even more difficult and dangerous in the right side because of the presence of the superior vena cava. Furthermore, the vessels and bronchus have shorter stems on the right side. The presence of tumor or large vascular nodes close to or overlying the artery makes this dissection extremely hazardous. An almost unmanageable problem may often be greatly simplified by opening the pericardium. Good lengths of the artery and the upper vein will usually be available then and will, of course, be free from fixation of any kind. A great deal of credit should go to Allison of Leeds, for emphasizing this and clarifying the anatomy from a surgical standpoint. The pericardium need not be closed afterward, but unless it is actually invaded an unnecessarily wide opening should not be made lest the heart herniate when the patient is turned. We have had the situation where we very much feared this accident but have not actually encountered it.

The pericardium is easily and safely entered just in front of and below the superior pulmonary vein and preferably dorsal to the phrenic nerve and its vessels. Frequently, however, the latter are pulled up into the hilum in this area and the incision must be made anterior to the nerve. After the pericardial fluid has been aspirated, the opening is widened up past the pulmonary artery to the base of the superior vena cava or onto the aorta in the region just central to the ductus arteriosus. This is done with the finger as a guide inside the pericardium. It will be found that the very lowermost portion of the superior vena cava can be identified as a discrete structure and the finger passed about it at the point at which it enters the right auricle. The pulmonary artery may then be securely ligated close to its origin by retracting the vena cava to the left. If, after the vena cava has been retracted to the left, the length of artery still appears to be too short for comfort, a good ligature may be placed medially on the pulmonary artery and the arterial dissection abandoned temporarily until the veins have been disposed

of. The location of the superior pulmonary vein is such that it interferes with the intrapericardial dissection of the artery. The latter dissection is much simplified by dividing the vein first, but obviously this is undesirable. Accordingly, if circumstances make it expedient, the disadvantage of tying the vein first may be circumvented by placing one ligature upon the artery.

The superior pulmonary vein is easily handled within the pericardium. It is a stout structure, unlike its extrapericardial components. As the auricular wall is approached, the wall of the vein itself becomes more muscular, more fibrous and is much more suitable for secure ligations. The index finger may be insinuated about the vein and the filmy pericardial reflections readily divided. A good length is then available for transfixion and division. At this point at times tumor propagations within the veins may necessitate resection of small portions of auricular wall. It is not difficult to include auricular wall in the deepest number 1 chromic ligature. Distal to this, a running suture of silk is used, or a silk transfixion suture, depending on how much auricular wall is excised. A distal transfixion suture is then employed and the vein severed.

With the veins freed, the artery may be more easily transfixed and cut away on a distal clamp. The latter is carefully oversewn to prevent back bleeding. By this intrapericardial technic the right pulmonary artery may actually be ligated very close to the point of bifurcation of the main pulmonary artery.

On the left side, good lengths of pulmonary artery are much easier to obtain, although the ductus arteriosus usually requires section. We have not found it necessary to divide the vestigial fold of Marshall. If the superior and inferior mediastinal dissection has been carried out as suggested, the trachea will be clean and it then remains to ligate the bronchial arteries high, and clean out all loose tissue and nodes from the carina and under the contralateral bronchus. The bronchus is divided so that the uppermost suture is placed high on the tracheal wall and the lowermost suture is actually at the carina. Thus the line of section is parallel with the trachea itself. With this type of dissection there will seldom be any tissue available with which to cover the bronchial stump. A wide flap of parietal pleura should be mobilized and turned over on the stump.

QUESTION OF DRAINAGE

Most surgeons do not believe that drainage of the thorax after total pneumonectomy is necessary. In all these cases we place a catheter in the chest cavity, with dependent drainage under a water trap without suction. This is done to avoid mediastinal shift. The latter may occur suddenly or develop insidiously without its presence being realized until irreversible cardiorespiratory damage takes place. If suction is not applied, very little fluid is lost. We have had no cause to regret this procedure.

SUMMARY AND CONCLUSIONS

Many serious technical problems may arise in the course of a total pneumonectomy. Some of the measures which we have found useful in dealing with these difficulties are described. In addition, it was thought worth while to point out that certain extensions of the standard pneumonectomy may be applicable in certain circumstances with good results and without unduly increasing mortality.

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PARTIAL LUNG RESECTION: SURGICAL CONSIDERATIONS

DAVID P. BOYD

INTRODUCTION

With the introduction of the antibiotics a change took place in the type of case considered suitable for partial lung resection. Ten or fifteen years ago only cases of severe bronchiectasis characterized by debilitation and copious offensive sputum were considered for lobectomy. Tuberculosis was not thought to be a suitable disease for extirpative therapy and lung abscess was treated in a somewhat unsatisfactory manner by external drainage. The introduction of sulfonamides and penicillin, with the consequent reduction in the number of cases of serious lobar pneumonia and unresolved pneumonia, has diminished greatly the incidence of serious lung abscess and extensive purulent bronchiectasis. Today, on the other hand, we encounter a milder type of bronchiectasis which nonetheless is provocative of marked symptoms. These are in the nature of recurrent respiratory infections, bouts of atelectasis and at times pulmonary hemorrhage. These cases of bronchiectasis and many cases of chronic lung abscess are suitable for partial lung resection. Furthermore, it is now believed that certain cases of tuberculosis are suitable for segmental or lobar resection. These are the cases in which the disease has remained localized to one segment or lobe and they represent instances of a relatively high degree of resistance to the disease on the part of the patient. Many of these patients have the localized foci of caseation and calcification which are known as tuberculomas.

Localized infectious disease in the lung characterized by dilatation of bronchi with puddling or localized areas of atelectasis is considered an indication for surgical treatment. The presence of bilateral disease with marked symptoms imposes a heavy load on one's diagnostic facilities. Thus it will be essential in such cases to delineate every segment in the chest in order to know precisely what is diseased and what can be spared. After this has been done it will be necessary to balance the severity of the symptoms against the increased risk and morbidity associated with bilateral intrathoracic operations.

The technics which are described herewith are not at great variance from those which are accepted as satisfactory by thoracic surgeons. Inasmuch as they are based on a large experience with partial lung resection, however, it is thought that they are worthy of presentation. There are many tricks to performing operations in critical areas and particularly under certain technical handicaps which are difficult to describe, but which nevertheless contribute greatly to the smoothness and to the success of the procedure.

PREOPERATIVE CARE

In suppurative lung disease a long period of preoperative preparation is essential. This will vary from several days to a week or even more in bilateral cases

and consists of the administration of antibiotics in order to arrive at a point where the tracheobronchial tree is as dry as possible. In bilateral disease it has

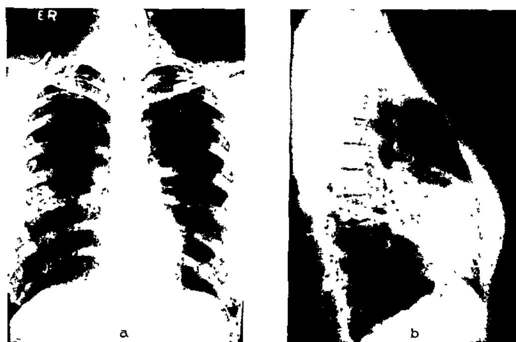


Fig. 136. Cystic disease in mid zone of the right lung; *a*, postero-anterior view; *b*, lateral view.



Fig. 137. Lateral view after instillation of lipiodol (see Fig. 136 and text).

been our belief that the more involved side should be operated on first, contrary to the recommendation of some authors. Probably six to twelve months should

elapse between operations in the bilateral case and careful re-evaluation should be done before the second operation. This evaluation should include studies on pulmonary function and particular attention should be given to allergic manifestations which might further reduce an already impaired vital capacity.

The preoperative study of the bronchogram is of great importance. As previously indicated, every segment should be visualized. As a rule the lobar and segmental arteries will approximate in their anatomic configuration the bronchial radicals which are visualized. Particular attention should be paid to the length of the intermediate bronchus and the relationships of bronchi to be removed to bronchi to be spared. Thus, before the incision is made the surgeon has a general idea of the problems which may be encountered.

There is one particular instance in which the preoperative study of the bronchogram is not helpful and, indeed, may be misleading. This is in congenital cystic disease of the lung in which symptoms caused by infection or hemorrhage may require lobectomy or segmental resection. Thus, in the case depicted in Figures 136 and 137, after careful study of the bronchogram a diagnosis of cystic disease of the lung, with hemorrhage, was made, with involvement of the superior segment of the right lower lobe, both segments of the middle lobe and the an terior segment of the right upper lobe. This would appear to be a reasonable diagnosis on the basis of the bronchogram. At operation, however, it was found that the cysts were entirely in the superior segment of the lower lobe which had enlarged and compressed the middle lobe and the anterior segment of the upper lobe out of the way so that in the films these cysts simply overlay perfectly normal tissue in the anterior segment of the upper lobe and in the middle lobe.

THE OPERATION

The Problem of Exposure

There are no short cuts to a good exposure in the thorax, and except in young children in whom deformity is a consideration, intercostal incisions are not used. Time must be taken to make a sufficiently wide incision and this will require resection of a rib from the transverse process to the costal cartilage. In addition, it will often be necessary to remove a small piece of the rib above and of the rib below. Although unnecessary trauma to large muscles is to be avoided, in upper lobectomies it is essential to extend the incision up between the scapula and the spine almost as far as the transverse spine of the scapula. This necessitates considerable division of the trapezius and the rhomboids but is most effective in improving exposure. After the chest has been opened, the first problem in securing exposure is dealing with adhesions. All adhesions between the visceral and parietal pleura and between the pleura and the pericardium should be divided at the start. If it is apparent that these adhesions are vascular, the anesthetist should be advised, because a great deal of blood can be lost during this stage of the operation. Many of these adhesions are filmy and avascular and can be freed quickly. If they are vascular adhesions, however, there is no quick and easy way of dealing with them. Many of them must be tediously ligated and divided, but if the division is not performed too close to the parietal pleura, many small bleeding points can be controlled with hot packs.

The Development of the Interlobar Fissure

Interlobar fissures vary from the simple case in which the fissure is complete to the situation in which it is almost impossible to find any fissure. As a rule some vestige of a fissure will be found even if it has been obliterated by adhesions, and with careful dissection a reasonable line of transection will be found. At times many small veins cross the fissures from lobe to lobe and it is impossible to secure these individually. All that can be done in this situation is to work from field to field, using hot, moist packs and pressure in the interim to control oozing. This usually is effective except for large fissure veins which can be individually ligated. As a rule, it will be possible to complete the fissure before proceeding to the dissection of the hilum. If the fissure is completely rudimentary, however, an attempt should be made to find the artery and tie it before going on with the dissection.

The Dissection of the Artery (Figs. 138 and 139)

The lobar artery is found in the depths of the fissure. It may show glistening through the visceral pleura or it may lie very deep in pulmonary tissue. Fre-

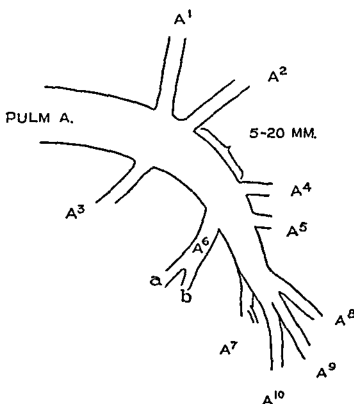


Fig 138. Diagram of right pulmonary artery.

quently it is obscured by overlying lymph nodes. In fact, lymph nodes may well be sought as a clue to the location of the artery. The intermediate artery must be dissected out cleanly. It is only in this way that secure ligatures can be placed without any danger of slippage. Furthermore, by dissecting out the entire intermediate artery, the branches to the segments which are to be spared may be

clearly visualized. The most useful single maneuver is to dissect down to the adventitia of the artery well out in the branches of the vessel to the segments to be resected. Then in the correct cleavage plane one may work up to the intermediate artery. This simple device will convert an extremely difficult procedure into a manageable one and nodes, lung and adherent bronchus may be lifted off the artery with safety. The field may be obscured by fibrosis, by large, soft, or firm nodes, or by many small bleeding veins in surrounding parenchyma. It is essential to continue the dissection until the adventitial plane is reached. It

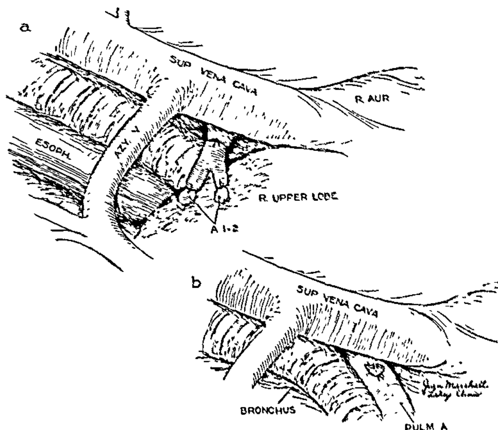


Fig. 139. *a*, The early dissection of the upper lobe artery. The main pulmonary artery was unusually small in this case. *b*, A further stage in the upper lobe dissection.

may again be necessary to change the field and place hot, moist packs and use pressure from time to time. In many cases the arterial branches are short and thick, especially the middle lobe arteries, and it may be almost impossible to secure them. It is well then to divide all the bronchi, that is, to the middle lobe and to the upper lobe or the lower lobe if either of these is to be sacrificed, and then cut the middle lobe away without distal ties. In more difficult cases the main pulmonary artery may be isolated and temporarily occluded by a Blalock clamp, following which the short arterial stumps may be handled with greater ease. Temporary occlusion should be done in any difficult lobar dissection, so that if a tear occurs in the main trunk artery, pneumonectomy will not be necessary since the artery may be repaired with fine silk stures in a bloodless field. Again it should be emphasized that every branch of the artery must be clearly seen.

The Dissection of the Bronchus (Figs. 140 and 141)

After the lobar artery is tied, it is pushed up on the bronchial wall out of the way. This is an exceedingly important point and is not difficult to execute once the proper plane of cleavage has been found in the dissection of the artery. The

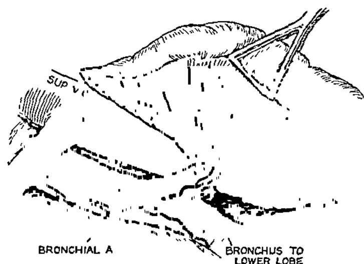


Fig. 140. After the artery has been secured the upper lobe may be turned forward and the bronchus dissected cleanly out as shown.

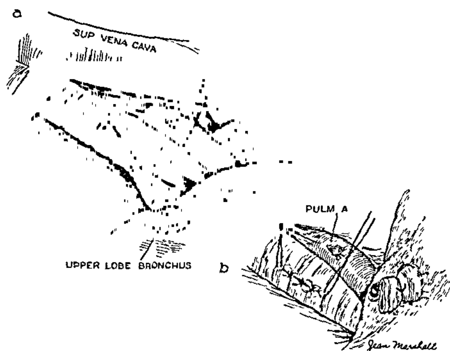


Fig. 141. *a*, By working from front and back, the bronchus may be divided, keeping the intermediate artery under direct vision. The middle lobe bronchus is seen. *b*, Final closure of upper lobe bronchus.

stump of the vessel can be wiped well up into the mediastinum and by this maneuver a good length of bronchus may be obtained. The bronchus itself must be dissected out so that the remaining bronchi are clearly visible. Bronchial arteries are then tied with fine silk on a French needle about a millimeter above

the proposed line of section which is demarcated by two silk traction sutures placed but not tied at the extreme ends. No stump of bronchus should remain. It should be divided flush and the line of division should be in the line of the remaining bronchus. The distal bronchus is occluded by a clamp or a transfixion suture of heavy silk or catgut. The suction tip is held in readiness and a small part of the bronchus is cut across. A right angled clamp is introduced into the bronchus to determine exactly how much stump remains and if this length is satisfactory, the small opening is closed with fine silk. This is carried across the bronchus until closure is completely effected. Before the chest is finally closed, this bronchial closure should be checked for air leak. It is usually possible to bury the stump or cover it with surrounding pleura or areolar tissue. If this is not possible, a flap of parietal pleura should be mobilized to cover the closed stump.

Dissection of the Veins (Fig. 142)

The inferior pulmonary vein can almost always be ligated as a trunk outside the pericardium and the development of the two major tributaries is not difficult.

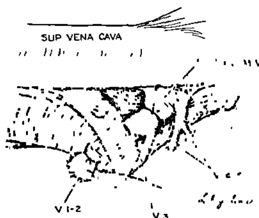


Fig. 142. The upper lobe veins are being secured after division of artery and bronchus.

The upper vein, however, is often very short and fans out widely over the upper and middle lobes. Occasionally there may be one common pulmonary vein. In the fissure, the most important point to remember is that the great venous radicals are often intersegmental and are easily injured. Thus the posterior apical segmental vein (V 3) is especially vulnerable on the under aspect of the upper lobe (Fig. 146, *b*).

The Technic of Upper Lobectomy

In accord with the general remarks already made, the fifth or sixth rib is widely resected in order to give good access to the apical segments of the lung. It is frequently necessary, however, to remove the middle lobe along with the upper lobe on the right side and consequently the rib resection should be carried well forward into the region of the costal cartilage. The field is prepared as previously indicated for the hilar dissection.

The apical segmental and anterior segmental arteries of the upper lobe (A 1 and A 2) are readily found and, as indicated in Figure 139, *a* and *b*, are divided between ligatures. A precise technic for these arterial ligations should be em-

ployed. A ligature of number 0 chromic catgut, well soaked, is first placed around the artery and tied as deeply in the mediastinum as possible. Following this, a transfixion ligature of medium silk is placed just distal to the chromic ligature. In many cases there will be adequate room in the distal vessel to permit a third ligature to be placed and the vessel cut between. If this is not possible, however, a clamp may be placed on the distal artery well out in the lung and the artery cut away along the clamp. The clamp itself may then be oversewn to avoid back bleeding. To avoid damage to underlying structures, especially veins which have not yet been satisfactorily visualized, ligated arteries should be divided over a

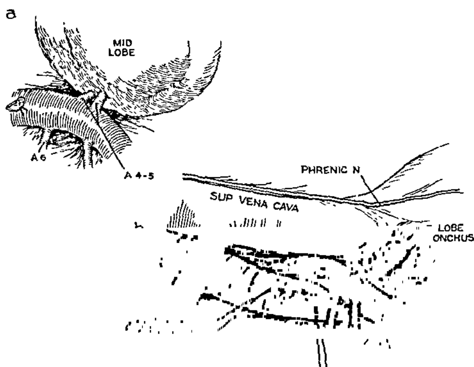


Fig. 143. *a*, The upper and middle lobes are held forward to isolate the arteries to the middle lobe. Its relation to the dorsal segmental artery of the lower lobe (A 6) is observed. *b*, Section of the middle lobe bronchus. The intermediate artery is in the way, as is seen, and is retracted, using a fine spatula. This permits high, smooth ligation of the bronchus.

partially opened right angle clamp. At times it may be necessary to ligate the veins which drain the upper lobe before the arteries can be effectively handled, although this is undesirable. Anomalous arterial branches are seen at times and are likely to be small, even tiny, and if they are torn, serious trouble may result because of the limited exposure available at this stage. After the apical and anterior segmental arteries are ligated, great care should be taken in dividing the artery to the posterior segmental branch. At this stage it will be apparent that the intermediate artery crosses under the upper lobe bronchus and over the lower lobe bronchus, and the middle lobe arteries may be quite inaccessible. Whether the middle lobe is to be resected or not, it is expedient at this point to divide the upper lobe bronchus as already described above. The arteries to the middle lobe and, in fact, the entire pulmonary artery are then apparent (Fig. 143, *a* and *b*). Very rarely, the artery to the posterior apical segment may arise from the superior segment to the lower lobe and occasionally one or both middle lobe veins may

drain into the inferior pulmonary vein. These and other anomalies must be watched for continually. As the artery is being followed down it is important to remember the posterior apical segmental vein referred to above (V 3), lest it be injured. This is the great upper lobe vein and lies deep on the under surface of the upper lobe in the heart of the great fissure (Fig. 146, *b*). The two veins and two arteries of the middle lobe are at times confluent, but often there are two separate trunk vessels to and from this lobe. The bronchus, on the other hand, is almost always one trunk. It is handled precisely as previously described and with as much care as the larger bronchi.

With the lobe removed, the bronchi, veins and the entire pulmonary artery should be apparent, with good stumps and all remaining branches visible.

The Technic of Lower Lobectomy (Figs. 144, 145 and 146)

It is well to begin again with the artery, but instead of working from above downward, the dissection is begun in the fissure. If the artery is not readily visible

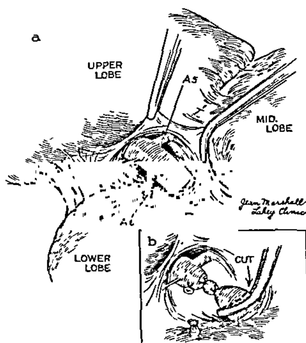


Fig 144. *a*, The hilar dissection at the start of a lower lobectomy. In this patient the artery was unusually large. Note that the middle lobe and dorsal segmental arteries are clearly seen before any ligations are carried out. *b*, The technic of arterial ligation.

it may be necessary to penetrate into pulmonary substance. If extremely vascular areas must be traversed in this dissection, the anesthetist should be kept apprised of the blood loss and the possibility of encountering further undue vascularity. If oozing is excessive the field can be temporarily abandoned and dissection of the veins begun. A deep, hidden, pulmonary artery may readily be located in the heart of the fissure if the surgeon simply looks for and palpates for enlarged lymph nodes. A node which overlies the intermediate artery and the node between the dorsal and basal division arteries are almost as constant as the arteries themselves. The nodes, of course, are vascular and troublesome, but if the adventitial plane of the artery is entered as described, these nodes can be quickly

lifted off and mobilized with ease. Since these nodes obscure the field, they should be excised after their small pedicle has been ligated. Entering the proper plane for arterial dissection is facilitated by using fine forceps similar to those used by neurosurgeons and fine, blunt, Metzenbaum scissors. With these forceps the areolar tissue may be picked up over the artery and incised with the curve of the scissors upward, and the arterial sheath entered, split and dissected. This

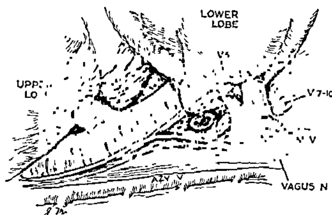


Fig. 145. The lower lobe vein with the segmental veins.

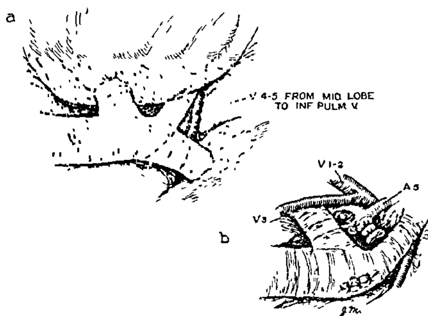


Fig. 146. *a,* Dissection of the lower lobe bronchus. Note that the middle lobe veins (V 4 and 5) drain anomalously into the inferior pulmonary vein. *b,* The separately ligated arteries from dorsal and basal divisions of the right lower lobe, the upper lobe veins V 1, V 2 and V 3; the lowermost middle lobe artery (A 5) and the ligated bronchial stump.

dissection should be begun as far distally as possible for added safety. This layer is followed up until both dorsal and basal division arteries are clearly seen and the origins of the arteries to the middle lobe appear. It will then be possible to separate the lower lobe artery from the underlying bronchus and obtain a good length for division. A number 0 chromic ligature, well soaked, is tied up against the middle lobe artery and a medium silk transfixion suture is placed just distal to this ligature. Distal ties may be separately placed and dorsal and basal division

arteries or clamps may be used and oversewn. After the arteries are divided and wiped up into the mediastinum, the middle lobe arteries will be visible and may be secured at this time. When one is working from below, the arterial stumps to the middle lobe may be so short that they cannot be safely secured. As an alternative to placing a Blalock clamp on the main pulmonary artery, as already described, which is possible after the upper lobe has been dissected down, in this situation it is better to use a soft, arterial, noncrushing clamp such as the Satinsky clamp to obtain temporary partial occlusion of the pulmonary artery. After the Satinsky clamp has been placed, the arteries to the middle lobe may be cut away with greater safety.

The bronchus is exposed and dissected up to the point where the main right bronchus divides. It is freed postero-inferiorly from the inferior pulmonary vein, dissected high and amputated flush. The bronchial arteries are found and carefully ligated to prevent aspiration of blood into the bronchial tree during closure. The lobe then hangs by the inferior pulmonary ligament and vein. The ligament is divided and ligated up to the vein and the latter doubly tied close to the pericardium. The proximal tie is heavy silk on a needle. The specimen may then be cut away on a distal clamp, leaving an adequate cuff. The inferior pulmonary ligament must be handled with care as rarely a large, anomalous, aortic branch artery may pass through it into the lower lobe.

The bronchial stump is tested for air leak and covered with adjacent pleura. The phrenic nerve is not crushed because we value the action of the diaphragm in the postoperative period. We believe that the diaphragm will reach its own level eventually.

In all cases drainage under water, with moderate suction, is instituted. In cases in which a lower lobe has been resected, a posterior catheter is considered adequate, while for those in which upper and middle lobes have been resected, two catheters are used, a posterior one to remove fluid and an anterior one to remove air.

POSTOPERATIVE CARE

The integrity of the remaining lobe is the chief problem in the convalescence of these patients. We have rarely seen shock in recent years, and these patients are warm, pink and dry throughout the operation and afterward. The dictum was laid down by Tudor Edwards many years ago that 9 out of 10 cases of postoperative lobar collapse are due to causes within the bronchial tree. This has been borne out by our experience. We pay careful attention, however, to the catheters and watch their function closely. As soon as the patient has been turned on his back while he is still in the operating room, a stethoscope is placed on his chest to determine whether breath sounds are adequate before the endotracheal tube is removed. Frequently, bronchoscopy will be necessary, especially in cases of bilateral disease. The chest is examined twice a day until the catheters are removed, usually about the fifth or sixth day. Roentgenograms of the chest are not usually taken after operation because they are confusing and difficult to interpret. We have learned to place more reliance on physical signs carefully elicited and sought for repeatedly. If the remaining lobes are not aerating, the catheters are checked at once and irrigated with penicillin solution, and the pa-

tient is encouraged to cough. The patient may be placed in position over the side of the bed and thumped on the back while the wound area is stabilized by an attendant. If this maneuver is ineffective, a small catheter is passed into the trachea through the nose and suction applied. This will almost always induce coughing and bring about re-expansion. If it does not, bronchoscopy is performed without delay. It is important that these patients be seen early in the morning in their immediate postoperative period so that prompt action may be taken, and in the late afternoon or early evening so that they do not go through the night with a plugged bronchus.

We have been gratified with the results of these simple but inflexible measures *There is no field of surgery in which close attention to detail and diligence in* watching patients will pay greater dividends than in cases of partial lung resection.

SEGMENTAL LOBECTOMY[1]

We have gradually taken the stand that, given definite but localized disease, whether it be cystic disease, bronchiectasis or abscess, a well performed lobectomy is the simplest and least complicated. Circumstances and the passing of time may change this opinion but inasmuch as we have encountered a decided increase in morbidity following resection of segments, we prefer to limit this operation to certain specific indications. The usual indication is bilateral disease. A projected plan of bilateral attack in bronchiectasis with conservation of segments places a heavy burden on one's diagnostic facilities. Bronchograms must be adequate. We prefer to take six films, namely a postero-anterior and true lateral with the more diseased side only filled, then with both sides filled, a postero-anterior stereoscopic and two oblique films. If necessary, roentgenographic examination is repeated until there is no question about the condition of every portion of the bronchial tree.

As indicated previously and as shown in the illustrations, it is not difficult to dissect the various segmental arteries. When they are divided and wiped up out of the way the segmental bronchi are revealed. When they have been secured in exactly the same manner as already described, the segment is ready to be stripped. It may be simple or it may be almost impossible to find a good cleavage plane between the segments. Certain clues may be available. Thus, a small incisura may indicate the peripheral demarcation of two segments, and often a diseased segment may show less anthracotic pigment than an adjacent normal one. The veins, always intersegmental, may be the clue to the cleavage plane, as pointed out by Ramsay.[2] The principle of segmental inflation and deflation, although limited in its usefulness because of the interalveolar communications, is, nevertheless, helpful and is used routinely. Sufficient air may pass through the interalveolar pores of Kohn to keep the segment inflated even with its bronchus tied. The diseased segment is separated by putting traction on the artery and bronchus, and is carried out with the greatest delicacy. The small fissure veins are secured with fine snaps and tied. The remaining ooze and air leak can be controlled by placing a warm pack on the raw lung. Sometimes a good line of cleavage can be developed by insinuating the finger along the bronchus, and an overhanging blanket of pleura may be left. We prefer, however, to accept small

air leaks and apply suction than to turn in, that is, pleuralize, the bare areas, since the goal is to conserve functional lung. If multiple segmental resections are carried out, that is, removal of segments of both upper and lower lobes, it may be necessary to fix the two lobes together with a few interrupted sutures in order to prevent torsion of the remaining segments.

CONCLUSIONS

Some of the important problems in the technic of partial lung resection have been presented. Emphasis is again placed upon the following considerations: (1) careful preoperative study to determine the precise extent of the disease, (2) adequate preoperative preparation for surgery, especially in cases of bilateral disease, (3) complete hilar dissection in every case in order to provide secure ligations of arteries, to insure short bronchial stumps and to guarantee the integrity of remaining vessels and bronchi and (4) careful postoperative management with special reference to the re-expansion of remaining lobes and segments and the elicitation of physical signs.

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THE SURGICAL TREATMENT OF EXTRAPULMONARY NEOPLASMS

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INTRODUCTION

The successful surgical management of extrapulmonary neoplasms is dependent upon their complete extirpation without trauma to the many important structures that lie in close relationship to them in the mediastinum. Many of these lesions are asymptomatic and are discovered during routine surveys utilizing x-rays. It is almost always impossible, however, to be certain of the exact pathologic condition represented by these roentgenologic shadows in the mediastinum. Thus, it becomes particularly important to distinguish and exclude nonneoplastic lesions which may produce similar roentgenologic shadows. These include such important lesions as mega-esophagus associated with long-standing cardiospasm or carcinoma, diaphragmatic hernia of the hiatus and parasternal types, arterial aneurysms, intrathoracic goiter and others.

Since the management of some of these lesions may be quite different from that of mediastinal tumors, barium studies of the esophagus should always be included. Fluoroscopy should be done and a definite attempt made to exclude a vascular lesion; if there is any doubt angiography may be considered. If these lesions have been ruled out as nearly as possible by the proper studies, the remaining abnormal roentgenologic shadows in the mediastinum must be considered neoplastic, and since exact pathologic diagnosis cannot be made preoperatively, exploratory thoracotomy must be done without delay. Many of these mediastinal lesions may prove to be benign, such as the various types of simple and dermoid cysts and some of the solid tumors such as neurofibromas and connective tissue tumors.

On the other hand, there is abundant evidence to indicate that many of these extrapulmonary mediastinal masses are dangerous from the standpoint of secondary infection and malignant degeneration. For example, Heuer and Andrus, in their classical survey of the literature on this subject, found that of 217 cases of dermoid cyst of the mediastinum carefully followed, 47 patients were not treated and all of them succumbed to their disease. Eighteen untreated cases of fibroma of the mediastinum, in which operation was not performed for one reason or another, were also followed and all of these patients died of this disease. In view of this statistical evidence of a relatively high mortality in patients not operated on, it is apparent that early operation is mandatory in all cases.

Intrathoracic nonpulmonary lesions may be grouped according to their location in the chest, that is, whether they are in the anterior, posterior or middle mediastinum. The common lesions of the anterior mediastinum are the teratomas, but lesions may be encountered which are of thyroid or thymic origin and occa-

sionally pleural or pericardial cysts are present. In contrast, tumors which are located in the posterior mediastinum are usually neurofibromas or ganglioneuromas arising from the intercostal or sympathetic nerves. Masses located in the middle mediastinum are most frequently primary or secondary tumors of lymph nodes or arterial aneurysms. Clues to the diagnosis of mediastinal lymphoma lie in the bilateral shadows so often seen, and the early development and rapid progression of symptoms. This is in marked contrast to the ordinary benign intrathoracic neoplasms which are frequently symptom-free until they reach a very large size. In addition, if there is still doubt, a test of therapy may be applied.



Fig. 147. *a*, Postero-anterior and *b*, lateral flat plates of chest showing anterior mediastinal tumor.

Lymphomatous masses in the mediastinum shrink very readily under deep roentgen therapy. Arterial aneurysms can usually be diagnosed on the basis of the history, physical signs and serologic tests combined with fluoroscopic examination of the chest.

The limitations of this rule of thumb classification of lesions according to location and the possible confusion of tumor with aneurysm are both illustrated by the following case report and roentgenograms.

Case 1. A woman of 64 years came to the clinic because a tumor had been discovered in her chest. She had no symptoms.

Roentgen examination (Fig. 147, *a* and *b*) revealed a circumscribed lesion in the anterior mediastinum which was considered to be a teratoma. At fluoroscopy, however, several examiners felt certain that the lesion pulsated.

In an effort to settle this point an angiocardiogram was done. Diodrast, 50 cc. of a 70 per cent solution, was injected into an exposed arm vein. Serial films were taken at short intervals, beginning about three seconds from the start of the injection (Figs. 148, 149 and 150). It was apparent from a study of the films that the shadow was extravascular (Fig. 150).



Fig. 148. Test film taken immediately before injection of dye. This is taken to permit comparative density studies of the lesion itself before and after angiography.

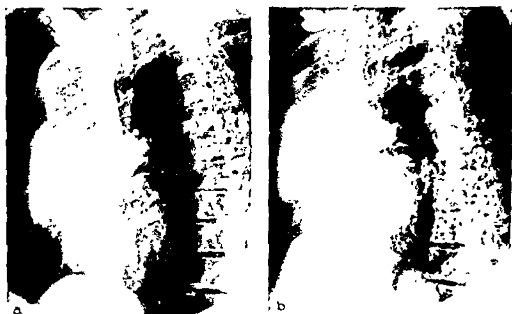


Fig. 149. *a*, This exposure shows the dye in the superior vena cava, right heart and pulmonary artery. *b*, Overlap of dye in right and left heart is apparent in this roentgenogram. The dye has entered the aorta.

With a provisional diagnosis of teratoma or thymoma, a right thoracotomy was performed and a solid tumor found. It was intimately connected to the ascending aorta and to the arch. Excision was accomplished without difficulty.



Fig 150. Entire ascending and transverse aorta is delineated and is seen to be separate from the mass. The latter has not changed in density. This is the film which is used to demonstrate the location of a coarctation of the aorta.

The pathologic report was neurogenic sarcoma of low grade malignancy.

The patient has been well since operation.

With these general considerations in mind, a more detailed consideration of the technical aspects is presented.

TUMORS OF THE ANTERIOR MEDIASTINUM

Many anterior mediastinal tumors of the dermoid and simple cyst types are easily handled by an anterior intercostal incision rapidly made and rapidly, if somewhat unsatisfactorily, closed. There are minimal trauma and no sequelae with this incision. In the female the incision can be made under the breast and thus be inconspicuous. The third interspace is entered, the internal mammary artery ligated and the second and third costal cartilages cut with a knife. This step avoids avulsion of the costochondral junctions by the spreader and permits more precise closure. On spreading the ribs the tumor is readily apparent lying on the pericardium, the great vessels or the lung root. The mediastinal pleura is incised longitudinally usually between the vagus and phrenic nerves, and these two structures protected. Frequently the cyst wall shells out without difficulty. The only trick is to keep trying successive layers until a true line of cleavage is

obtained. A true pedicle is unusual in these lesions and careful dissection will usually result in enucleation without difficulty.

The difficulties which are encountered in the removal of a dermoid tumor of the mediastinum are the result of secondary infection or malignant degeneration. It is said that approximately 12 per cent of these teratomas are the seat of malignant change. The presence of chronic recurrent infection may have resulted in dense fixation to neighboring structures, particularly the pericardium, the great vessels or the lungs. Occasionally the tumor will have broken into the pericardium or more frequently will have become so fixed to the lung that it has actually perforated into one of the lobes. Partial or total resection of the lung then is indicated to secure complete removal. It is in these cases in the past that surgeons have been compelled to resort to drainage and incomplete removal, usually with marsupialization to the exterior. The results, while at times gratifying, have usually been unsatisfactory. Occasionally, extreme vascularity may be a great technical handicap. This is seen in certain of the intrathoracic goiters. Some of the problems involved in the removal of anterior mediastinal tumors are illustrated by the following case reports.

CASE 2. This patient, a man, 42 years of age, was found to have a shadow in the anterosuperior mediastinum during a chest survey. Excision was recommended at the clinic but the patient declined. A year later he returned to the clinic and stated that he had had pneumonia and subsequent to this he had had persistent pain in the substernal area. Roentgenographic examination of the chest at that time revealed considerable change in the lesion detected one year before. Instead of being sharply outlined, the base of the lesion was ill-defined and showed areas of extension. At the time of operation great difficulty was encountered in freeing the tumor from the great vessels and the innominate vein was inadvertently opened. The tissue was so dense that a pathologic study by frozen section was made which showed only chronic inflammation. After a long and tedious dissection the entire lesion was finally removed and the patient left the hospital in good condition.

This case demonstrates the folly of leaving benign mediastinal tumors until secondary infection has occurred. The pathologic diagnosis in this case was simple pleural cyst with secondary infection.

CASE 3. A girl, 18 years of age, was admitted to the hospital with a preoperative diagnosis of left anterior mediastinal tumor. An operation had been performed elsewhere when the patient was 11 years of age. A tumor was said to have been found which involved the thymus. It was not removed. Radiation was administered.

At operation a dermoid tumor was found attached to the anterior mediastinal structures, abutting on the pericardium and the aortic arch, and extending into the anterior segment of the left upper lobe. The latter was not expanded. Resection of the anterior segment and the lingula of the left upper lobe and the adherent dermoid tumor was carried out. The pathologic report was teratoma with cyst formation and bronchial fistula. Chronic inflammation was evident throughout the lesion.

The patient's convalescence was uneventful and she was discharged on the thirteenth postoperative day. When she was seen five months after operation the chest was clear and there were no symptoms.

CASE 4. This patient, a priest 65 years of age, was known to have had a mediastinal tumor for ten years. In 1946 he was advised to have it excised but since he

had no symptoms he preferred to defer operation. In the spring of 1950 he began to note pain in his chest, which increased in severity, and after a few months some dyspnea was noted. Thus, four years after the first recommendation of operation, a change in the character of the symptoms was observed. When exploration was carried out at the clinic a large anterior mediastinal tumor was found invading the lower lobe of the lung, the pericardium and encircling the great vessels. On study of frozen sections this was found to be an epidermoid carcinoma, Grade 4. This tumor was considered to be malignant degeneration in a teratoma.

Occasionally transthoracic resection of a mediastinal goiter is indicated, particularly after an unsuccessful attempt has been made from the neck. If considerable time has elapsed since the thyroidectomy and particularly if the poles have been ligated in the previous attempt, the goiter gradually acquires vascularity from the mediastinum. This vascularity may be so profuse as to be almost impossible to manage. Such a goiter may be covered by large sinusoids and in intimate relation to the great veins of the superior mediastinum.

CASE 5. This patient, a woman 65 years of age, came to the clinic September 28, 1948, with the chief complaint of difficulty in swallowing and breathing of six years' duration. Twenty years previously subtotal thyroidectomy had been attempted for what was apparently an adenomatous goiter. Arterial ligation was performed. The patient was told that it was impossible to remove the gland because of excessive bleeding. For six years before coming to the clinic she had noted swelling in the neck and more recently dyspnea and dysphagia.

Upper mediastinal obstruction was indicated by the presence of many large veins in the arms and on the anterior chest wall. There was plethora of the head on lying down and the hands were red and somewhat swollen. On fluoroscopic examination a large circumscribed mass was present in the anterior mediastinum filling the entire upper half of the right chest and extending across the midline to the left just above the border of the aortic arch.

On September 30, 1948, the patient was admitted to the hospital. Digitalis was given because of auricular fibrillation. On October 5, 1948, a right posterolateral thoracotomy was performed. A large mass was encountered which extended from the neck to the right hilum, lying within the anterior and superior mediastinum. The azygos vein was stretched across the lateral portion of the superior vena cava across the medial portion of the tumor. This solid mass, approximately 10 cm. in diameter, was attached to the right and left lobes of the thyroid and almost completely surrounded the trachea. The tumor was mobilized by careful dissection, many large venous sinuses being encountered. The mass was detached from the right and left lobes of the thyroid and removed. Pathologic diagnosis was multiple colloid adenomatous goiter, the mass weighed 700 gm.

This patient's postoperative course was uneventful until the thirteenth postoperative day. At that time an elevation of temperature was noted. On November 1, the twenty-seventh postoperative day, respiratory difficulty developed and a roentgenogram showed widening of the mediastinum. A low-collar incision was made in the neck and a large abscess cavity entered which extended 12 cm. below the sternal notch. Subsequent to this, convalescence was uneventful and the patient was discharged November 23, 1948.

It is apparent from this case report that the technical difficulties in such a tumor may be very great. Surgeons who do this work must be experienced in

handling large blood vessels such as are encountered in few other conditions. Blood in large quantities must be available. Tedious, careful, sharp dissection without the use of finger or gauze is essential. All vessels are tied before division and gauze and gelfoam are applied for hemostasis. Unfortunately, electrocoagulation is usually not available because of the anesthetic mixtures which are employed. The excessive blood loss and resulting debility, the inevitable exudation and blood clot in the mediastinum so difficult to drain, and the large amounts of foreign hemostatic material, all predispose to infection. Superior mediastinal empyema may occur which is sealed off by the expanded lungs. This must be drained through the neck; no other approach is feasible.

CASE 6. This patient, a man 63 years of age, came to the clinic because of progressive fatigue. During careful medical study the diagnosis of myasthenia gravis was entertained and subsequently rejected. Roentgenographic examination of his chest, however, revealed a large, circumscribed, somewhat lobulated shadow in the anterosuperior mediastinum. This shadow protruded into the right hemithorax. It was thought that this might represent a carcinoma of the right upper lobe of the lung with mediastinal metastases. Accordingly, bronchoscopic examination was carried out but was entirely negative. Because the tumor occupied a portion of the right chest, right thoracotomy was performed and the lesion was removed with some difficulty. The pathologic diagnosis was malignant thymoma.

When last heard from in June 1949, two and a half years after operation, the patient was alive and well, without evidence of recurrence.

Tumors of the thymus are of great interest. This patient did not have myasthenia gravis but it is well known that there is a definite relationship between the thymus and myasthenia. Thus, we have seen marked alleviation of symptoms after total thymectomy in this disease. One patient who took two 15 mg. tablets of neostigmine every two hours now takes two to four tablets a day. In other cases, however, surgical removal of the thymus has not resulted in any improvement whatever, nor has there been any consistent correlation between thymic histology and the disease.

The surgical approach of choice to the thymus gland is by the transsternal route. Some of the operative difficulties encountered in Case 5 might have been obviated by splitting the sternum. This can be done, however, only when there is reasonable assurance that resection of the lung will not be required.

CASE 7. An unemployed waiter, with a history of four admissions for renal lithiasis, was readmitted with renal colic. It was learned that he had previously had pyelolithotomy on one side and nephrostomy on the other. When he was first seen his renal function was satisfactory but stones were present in the left kidney pelvis. Roentgenographic examination of his skeleton revealed generalized osteoporosis but no areas of truly cystic disease. The laboratory findings were highly suggestive of hyperparathyroidism and the Sulkowitch test was always 4 plus.

Exploration of the neck was carried out and a normal thyroid gland was found. After careful search two normal parathyroids were demonstrated, one on each side. The thyroid gland was small enough so that it was possible to be reasonably sure that no intrathyroid tumor was present. Therefore, a secondary skin incision was made from the center of the thyroid incision down to the third interspace. The sternum was then split to this level and divided laterally into the third interspace. After a small

spreader had been inserted excellent exposure of the anterior mediastinum was obtained. The thymus was small and no large lymph nodes were palpable. It is of great importance to palpate the mediastinum carefully and thoroughly before any dissection is done because the presence of dissected nodes and ligature material may be misleading. A tumor approximately 2 cm. in diameter was readily felt below the left innominate vein. To be certain that a second adenoma was not present within the substance of the thymus, the latter was removed. The sternum was wired together and the patient made a good recovery.

If the hypercalcemia and hypercalciuria are marked it has been our experience that the tumor will be large enough to be found without difficulty.

It is apparent from the case reports that the anterior mediastinum can be the site of an extraordinary variety of tumors. Some of the specific problems involved have been emphasized.

TUMORS OF THE POSTERIOR MEDIASTINUM

In contrast to the anterior mediastinum, tumors of the posterior mediastinum are remarkably constant in their pathologic character. They are almost all of neurogenic origin, although very occasionally a pleural cyst or esophagenic cyst may present in the paravertebral gutter.

The approach of choice for these tumors is the posterolateral one, preferably with resection of an entire rib. Osteotomy of the rib above and below adds greatly to the exposure and does not increase the disability. Great care is taken to dissect out the intercostal bundle and to divide and ligate this at each level where a rib is cut or removed. This is the most serviceable device which we have used for preventing wound pain. The latissimus dorsi must be cut across and in high lesions it is necessary to carry the incision up as far as the transverse spine of the scapula with section of the lower part of trapezius muscle. In the deeper layer the rhomboids and the serratus anterior may be split rather than divided. In any case no compromise must be made with exposure in these difficult cases. The erector spinae muscle is peeled oft the posterior border of the rib to be resected and also the rib above and below. This permits section of the rib close to the transverse process and preserves the erector spinae intact for postoperative stability. It also provides an excellent flap for closure of the defect at the posterior end of the incision. A self-retaining retractor is gradually opened over a period of several minutes to provide the maximum exposure of the thoracic cavity.

Most of these tumors are found in the costovertebral gutter. Here again these lesions may be shelled out readily or may present the most trying surgical problems. The mediastinal pleura is incised longitudinally and tension sutures may be used to hold the flaps apart. At the lower levels fixation to the diaphragm, the lung root, the esophagus or aorta may be very dense. At the upper levels these tumors may involve the great vessels of the superior mediastinum or the brachial plexus. They may even surround the subclavian vessels and pass up into the neck. The tumors which have been commonly known as neurofibromas arise from the spinal or intercostal nerve sheaths, and the tumors which are called ganglioneuromas arise from the sympathetic chain. In either instance they may actually invade the intervertebral foramen, giving a characteristic dumbbell configuration. Occasionally these tumors cannot be entirely removed through the

thoracic approach but require laminectomy in addition. The head of the rib can be removed, however, and the tumor excised down to the dura transthoracically.

Specific case reports are presented to illustrate these different problems.

CASE 8. A patient, 23 years of age, came to the clinic because of a tumor of the right mediastinum. Because of its location in the paraspinal area it was thought to be a neurofibroma. At operation the tumor was approached through a right posterolateral incision through the bed of the seventh rib. A solid tumor, approximately 10 cm. in diameter, was found and was thought to arise from the eighth intercostal nerve on the right side near the exit from the dura. It was attached along the vertebral column by a wide base between the seventh and twelfth dorsal vertebrae in the right costovertebral sulcus. There was moderate vascularity. No attempt was made to close the pleura. There was a small spinal fluid leak during the removal of the tumor which was carried out without difficulty. The pathologic diagnosis was ganglioneuroma.

Convalescence was uneventful and the patient was discharged on the thirteenth postoperative day. Two months later the chest was clear.

A more complicated type of posterior mediastinal tumor is exemplified by the following case report.

CASE 9. A patient, 42 years of age, came to the clinic because of a mediastinal tumor on the right side. There was associated bronchial compression and atelectasis of the right upper lobe. A right posterolateral approach was made through the bed of the sixth rib with osteotomy of the fourth and fifth ribs. A posterior mediastinal tumor, measuring 10 by 12 by 11 cm., was found, and the right upper and the right middle lobes were collapsed. There was also some pressure necrosis of the fifth and sixth ribs posteriorly, with some pleural fluid. The size of the tumor and its extreme vascularity made excision tedious and difficult. After the lesion was removed, however, the right upper and middle lobes expanded readily, and therefore they were not disturbed. The pathologic diagnosis was neurofibroma arising from an intercostal nerve sheath.

Convalescence was uneventful and the patient was discharged on the fifteenth postoperative day. When last seen the patient was well and the chest was clear.

Perhaps the most complicated type of posterior mediastinal tumor is represented by the following case report.

CASE 10. A patient, 30 years of age, came to the clinic because of a spinal cord tumor at the level of the third and fourth thoracic segments. Laminectomy was performed. An extradural tumor was found which extended into the intervertebral foramen on the left of the second and third thoracic segments. All possible tumor was removed.

At subsequent thoracotomy a tumor of the posterior mediastinum, approximately 4 cm. in diameter, was found just lateral to the fourth thoracic foramen. The intrathoracic portion was easily removed. The pathologic report was atypical ganglioneuroma of low grade malignancy.

When the patient was seen three years after operation the chest was clear, there were no neurologic symptoms and no evidence of recurrence.

Of the last 23 neurogenic tumors removed at the Lahey Clinic 2 have been definitely malignant and one questionably so. This figure of approximately 10 per cent is considerably lower than some reported series (for example, Kent, 37 per cent of 105 cases), but is nevertheless sufficient to emphasize their danger

After the tumor has been excised and hemostasis secured, the pleura is closed loosely if possible. The lobes of the lungs are re-expanded and inspected carefully for air leaks. The chest wall is closed with great care. A continuous fine chromic suture is used for the pleura and intercostals, with fine chromic interrupted sutures in the muscles. Pericostal sutures have not been used. Drainage is instituted in all cases, the catheter being inserted, as a rule, in a space below the incision and its location varying with the location of the tumor. As the closure is being made the catheter is connected to a bucket of water so that the lung may be completely expanded under vision. Positive pressure is maintained until the chest wall is air-tight. The tube is left in place in the thorax until the lung is completely expanded and drainage has ceased.

CONCLUSIONS

Inasmuch as precise clinical diagnosis is not always possible and as a rule nonsurgical lesions may be excluded by careful study, all extrapulmonary neoplasms should be promptly explored. Some of the more important surgical problems and points in technic are presented.

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THE GENERAL TECHNICAL ASPECTS OF CARDIOVASCULAR SURGERY

HERBERT D. ADAMS

Cardiovascular surgery received a tremendous impetus during the recent war years. Knowledge gained by experience with serious traumatic cardiovascular lesions familiarized us with the problems and technical aspects of this field of

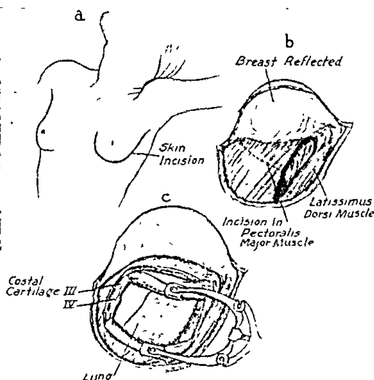


Fig. 151. Anterior approach for exposure of patent ductus arteriosus.

surgery. In addition, during these same years came the outstanding contributions of Taussig, Blalock, Gross, Crafoord and others in the surgical treatment of congenital cardiovascular lesions. Since that time the technical aspects of cardiovascular surgery have become more standardized, with constantly improving results and widening scope. Even intracardiac lesions are now beginning to be attacked surgically, and this whole field of surgery is changing rapidly. Some of the general technical aspects of the more common cardiovascular operations are, therefore, presented.

A brief reference to *arterial aneurysm* and *arteriovenous aneurysm* should be included in any discussion of cardiovascular surgery. In certain selected cases an arterial aneurysm can be mobilized and wrapped with polyethane. In others, the

Originally published in Surgical Clinics of North America, 29 705–715 (June) 1949.

vessel can be ligated and the aneurysm excised or, more recently, excision of the aneurysm with free arterial graft may be possible.

Arteriovenous aneurysms, either traumatic or congenital, in most instances are best handled by quadruple ligation and excision. In some locations such as the

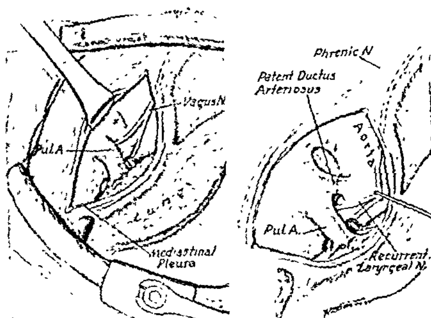


Fig. 152. The mediastinal exposure of the patent ductus arteriosus and its relationship to the recurrent laryngeal nerve.

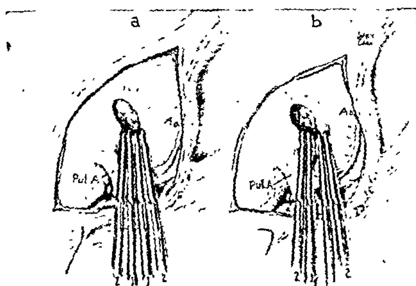


Fig. 153. The application of four clamps to the ductus and division between the two central clamps.

carotid, popliteal artery or aorta, aneurysmorrhaphy or, better, excision and free arterial graft, is preferable because of the serious circulatory complications that arise following ligation of these particular vessels.

Of even greater interest at the present time are the operations for congenital cardiovascular lesions, including patent ductus arteriosus, coarctation of the aorta and pulmonary stenosis. The earliest surgical attempts at obliterating a

patent ductus arteriosus were done by exposure of the ductus and simple ligation.[4,6] This method did not prove to be entirely satisfactory since there were recurrences following this simple ligation and, therefore, two other more satisfactory methods have been devised. Gross has developed and perfected the technic for complete division of the ductus and we have used this procedure very satis-

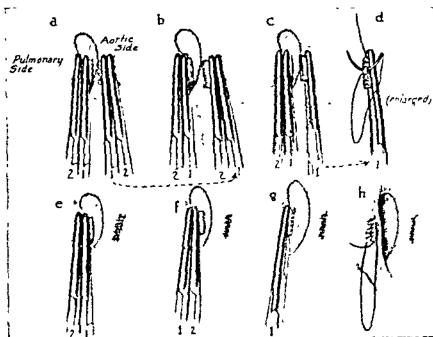


Fig. 154. Detail of suture of the cut ends of the ductus by successively removing the two distal clamps and suturing the protruding cuff beyond the two proximal clamps.

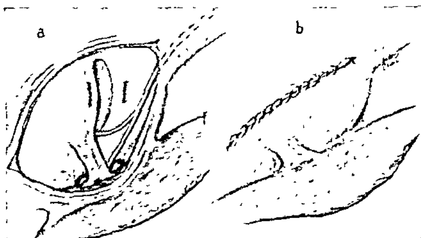


Fig. 155. The proximal clamps have been removed and the mediastinal pleura closed.

factorily in children. This consists of an anterior approach (Fig. 151). The mediastinum is opened and the patent ductus localized by palpation for the thrill and by its relationship to the vagus and recurrent laryngeal nerves (Fig. 152). It is then very carefully mobilized, particularly in freeing it up posteriorly. The ductus is also carefully mobilized in its full extent well back onto the pulmonary artery and the aorta, and all extensions of the pericardial sac are freed from it. Four thin clamps are then applied to the ductus and the ductus cut across between the two central clamps (Fig. 153). In succession, the two distal clamps are

removed so that the protruding cuff may be closed with continuous sutures (Figs. 154 and 155). This procedure does have the disadvantage of the possibility of

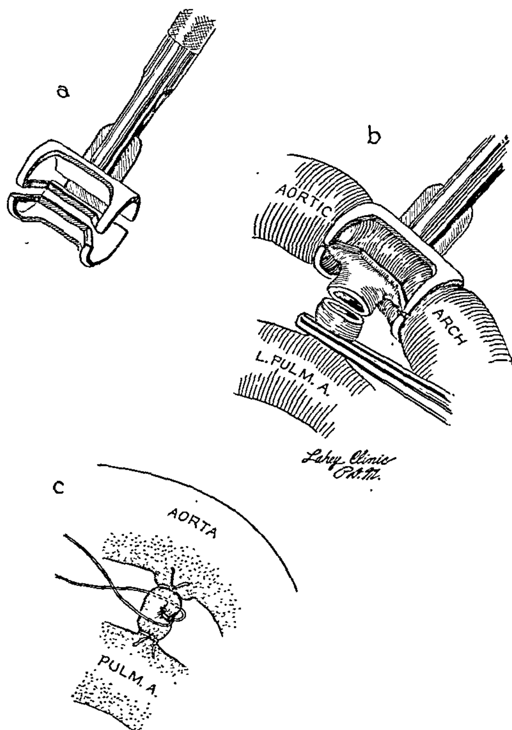


Fig. 156. *a*, Potts' clamp. *b*, Application of Potts' clamp to aortal end of the patent ductus arteriosus. A hemostat is applied to the pulmonary end and the ductus divided for suture closure. c, Ligation of aortal and pulmonary ends of the ductus with a transfixion ligature between

one of the remaining clamps slipping off during closure either because of application of a poor clamp or because of friability of the wall of the ductus, and we

have not felt that it was safely applicable to adults. We have, therefore, adopted the method of ligation suggested by Blalock (Fig. 156, *c*) by ligating the ductus as close as possible to the aortal and pulmonary ends and using a transfixion suture ligature between these two ligatures. In some instances in which it has been impossible technically to place the transfixion stitch because of the shortness and large diameter of this ductus, these ligatures have been wrapped with

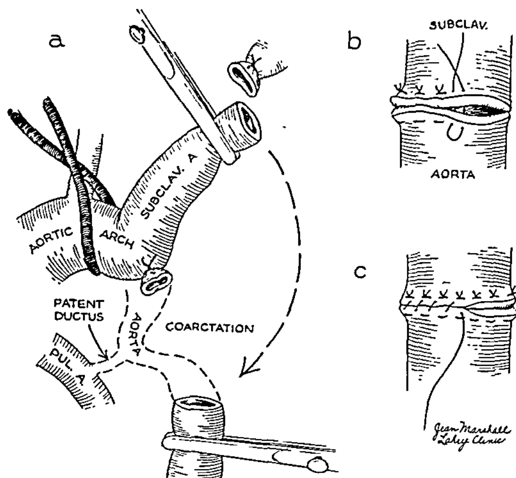


Fig. 157. *a*, Resection of coarctation and mobilization of subclavian artery for end-to-end anastomosis with descending thoracic aorta *b*, Detail of end-to-end anastomosis; everting interrupted sutures around entire circumference. *c*, Everted edges reinforced with continuous sutures, each covering half the circumference (Published with permission of the Journal of the American Medical Association, from "Coarctation of the Aorta," by Drs. Herbert D. Adams, David I. Rutledge and Carlton R. Souders, J.A.M.A., February 5, 1949.)

umbilical tape or polyethane. Recently we have considered using a reverse Potts' technic, employing a posterolateral approach, mobilizing the aorta and the ductus, and applying a Potts clamp across the aortal end of the ductus (Fig. 156, *a* and *b*) and a small clamp on the pulmonary side. The ductus is then divided, leaving sufficient stump at either end for easy and safe closure.

In a similar way, in our surgical management of *coarctation of the aorta* we have had to alter to some extent the technical aspects of these operations as we have applied these procedures to the higher age groups. In these cases, particularly in patients over 30 years of age, the aorta is thinned out, friable and contains considerable arteriosclerotic changes and plaques and therefore we have

not thought that it was advisable to depend for our anastomosis on simple running, everting sutures. Using a posterolateral approach, in the coarctations of

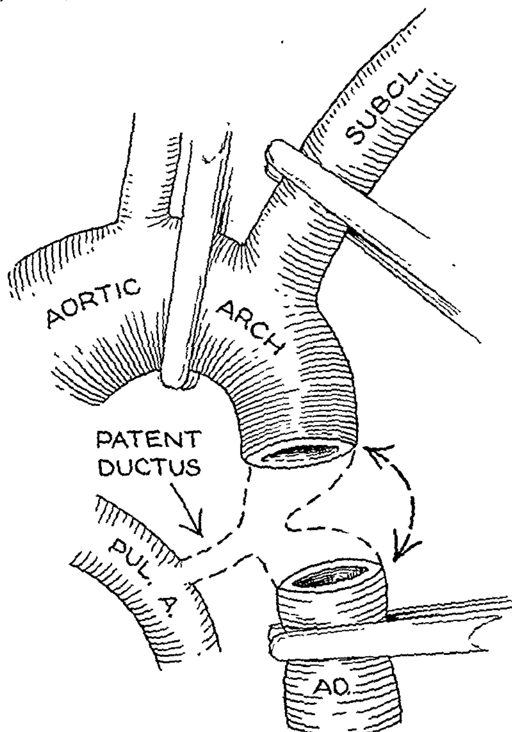


Fig 158. Resection of the coarctation and primary end-to-end anastomosis of the aorta. Detail of anastomosis as in Figure 157, *b* and *c*. (Published with the permission of the Journal of the American Medical Association; from "Coarctation of the Aorta," by Drs Herbert D. Adams, David J. Rutledge and Carlton R. Souders, J.A.M.A., February 5, 1949.)

greater length, around 1½ inches, we have done a resection and have mobilized the greatly enlarged subclavian artery and swung it down to do an end-to-end anastomosis with the aorta. This anastomosis is made using interrupted everting

sutures around the entire periphery of the anastomosis and then reinforcing this with a running stitch, whipping over the everted edges, each stitch going half way around the circumference (Fig. 157). In coarctations of shorter length we have resected this coarctated area and done a primary anastomosis of the aorta, using the same technic (Fig. 158).

In *pulmonary stenosis in the tetralogy of Fallot* we have again been dealing with the older age groups and have found the vessels more difficult to handle because of their greater friability and decreased elasticity. However, we have employed the Blalock technic, utilizing either the right or left subclavian artery for anastomosis with the corresponding pulmonary artery (Fig. 159). Using an

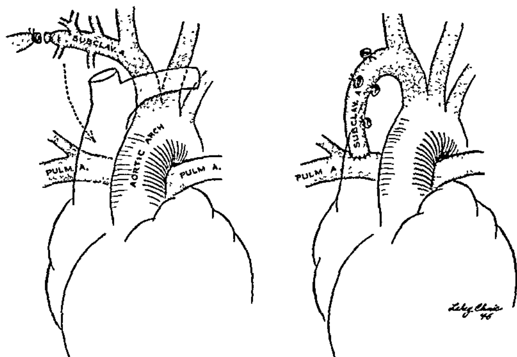


Fig 159. Pulmonary stenosis. Right subclavian-pulmonary artery shunt.

anterior approach, the mediastinum is opened and the subclavian and pulmonary arteries are mobilized and in most instances the end of the subclavian is anastomosed to the side of the pulmonary artery, using a single row of simple over-and-over sutures, each continuous suture covering half of the circumference of the anastomosis (Fig. 160). We have not used the Potts technic, producing an aortal-pulmonary fistula by use of his ingenious clamp, but there are probably instances in which this technic would be the one of choice and we have been prepared to use this method if it was impossible to use the Blalock procedure for any reason.

For completeness, it is well to mention the fact that various surgical procedures are now under development for the surgical management of mitral stenosis. These consist primarily of valvotomies and shunt operations such as the production of an artificial atrial septal opening, or a shunt between the systemic veins and the pulmonary veins.

Intracardiac surgery, however, is still done blindly and is, therefore, greatly

limited, and it will remain for the development of an artificial method of bypassing the heart so that intracardiac surgery may be done under direct vision and with highly accurate technic.

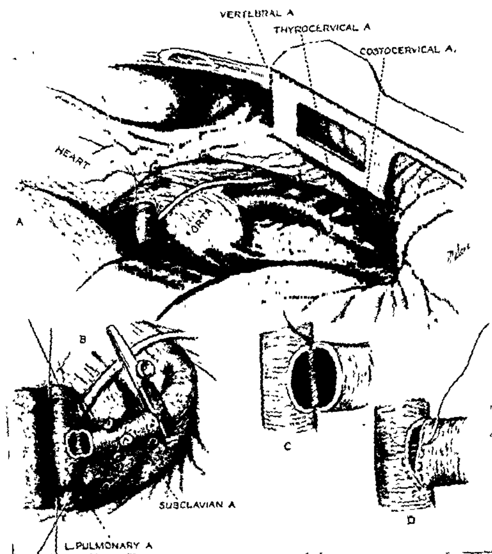


FIG 160. Pulmonary stenosis. Left subclavian-pulmonary artery shunt. *a*, Exposure of subclavian and pulmonary arteries. *b*, Detail of control of the vessels during the anastomosis. *c* and *d*, Detail of sutures used in anastomosis.

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COSTOSTERNOPLASTY WITH RIB STRUT SUPPORT FOR FUNNEL CHEST IN ADULTS

HERBERT D. ADAMS

Funnel chest of varying degrees occurs in adults and there is no question but that in the more marked degrees of this condition, sufficient displacement and distortion of the heart and its associated structures are present to cause a serious

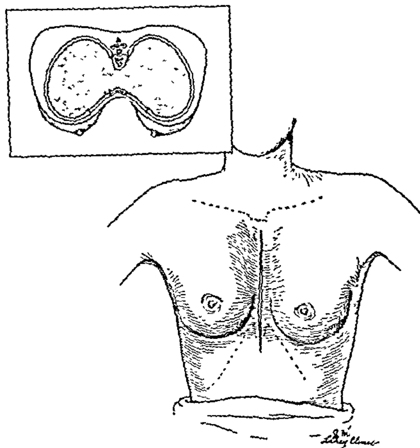


Fig. 161.

disturbance of cardiac function. This is evidenced clinically by tachycardia, arrhythmia, substernal distress and dyspnea on exertion. Until recently we have not been in favor of advising surgical correction of this condition for cosmetic reasons only or for purely potential cardiac impairment, primarily because of the magnitude of the operation and because an entirely satisfactory and reliable operation has not been available for this condition in adults. We have been far from satisfied with the results obtained by the various methods of mobilization of the sternum and suspension to external bridges of different types.

At the twenty-ninth annual meeting of the American Association for Thoracic

Originally published in Lahey Clinic Bulletin, 7:111–116 (April) 1951.

Surgery at New Orleans in March 1949, Daily, in his discussion of a paper on this subject by Lester, reported a case in which he had used a rib graft to elevate the sternum. A segment of the ninth rib with its periosteum was removed, all costal cartilages were excised, preserving the perichondrium, and the sternum supported by the rib graft. At the following annual meeting in 1950 Dorner reported a case, using a similar technic. We have thought this a significant contribution to the solution of this problem and have adopted the basic principle involving the use of a rib graft to support the elevated sternum. We have encountered such marked deformity of the sternum itself and the anterior ends of the ribs, however, that we have come to the conclusion that simple elevation of the deformity as a whole is not entirely adequate and have, therefore, added other

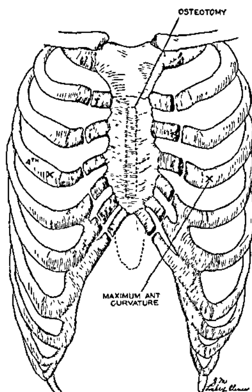


Fig. 162.

important details to the operation. Likewise, in order to avoid the second incision used to obtain the rib graft and thereby adding to the rather extensive disturbance in the thoracic cage and the wide dissection of tissue planes necessitated by the complete mobilization of the sternum, we have used a rib graft, stripped of its periosteum, from the bone bank.

A midline incision (Fig. 161) is made from the mid manubrium to just beyond *the inferior tip of the xiphoid process in the epigastrium.* The subcutaneous fascia is incised in the same line and the pector uscles freed and elevated from the sternal margins and costal cartilages t the costochondral junctions and beyond the po of maximal anterior of the ends of the ribs. The xiphoid proce zed and excised. costal cartilages and the inner ends of tl ond the point nterior curvature are freed up, leaving the um and perio The c ages are transected (Fig. ately 1 inch al the

sternum carefully elevated from the mediastinal structures. The sternum can then be raised to about a 45 degree angle so that its under surface can be fully visualized. An osteotomy or an incision at the sternal-manubrial joint has not

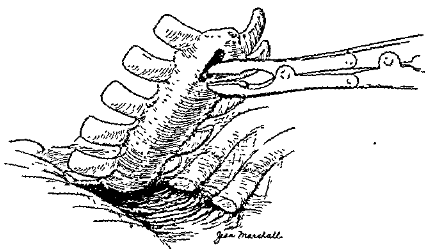


Fig. 163.

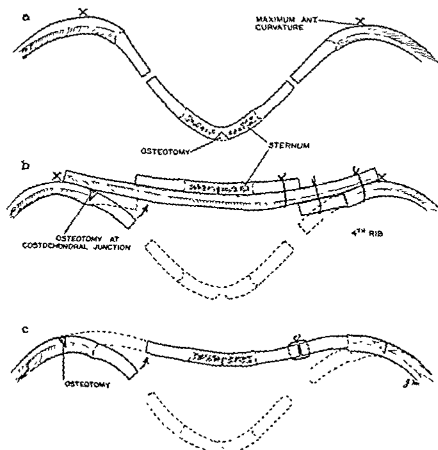


Fig. 164.

been necessary and we definitely believe that this joint should not be disturbed in order to maintain an adequate blood supply to the fully mobilized sternum. The anterior surface of the sternum is concave and the posterior surface is convex, often even wedge-shaped. This deformity can be readily overcome by mak-

ing a longitudinal osteotomy through the posterior surface of the sternum by biting out a groove (Figs. 163 and 164, *a*) in the posterior cortex of the bone with a narrow gooseneck rongeur. The sternum can then be bent flat since the anterior cortex will give sufficiently to permit this to be done readily.

A segment of a rib from the bone bank or, if this is not available, the anterior segment of the ninth rib, removed prior to the sternal mobilization, is placed beneath the sternum at the level of the fourth ribs. The slight concavity of the rib strut is anterior and the graft must extend between the two points of maximal anterior curvature (Fig. 164, *b*) of the inner ends of the fourth ribs on either side. It is cut to this length and a small hole drilled near each end. A similar small hole is drilled through the fourth rib on each side just medial to its point

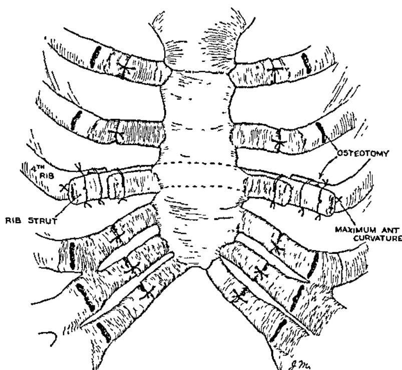


Fig. 165.

of maximal anterior curvature. The rib graft is secured in place by two number 1 silk sutures placed through the holes at each end of the graft and the holes in the fourth ribs near the point of their maximal anterior curvature, each suture encircling the rib before being tied (Figs. 164, *b*, and 165). Before securing the graft, however, a small osteotomy is made on the anterior surface at the costochondral junction of the fourth rib on each side, so that these sections can be straightened out to lie parallel to the under side of the rib graft. Both ends of the sectioned cartilages of the fourth rib on each side are secured to the graft by transfixing the cartilage with a number 1 silk suture and encircling the graft (Figs. 164, *b* and 165). The graft is thereby secured at three points on each side which results in excellent stability of the graft and the sternum. All of the remaining cartilaginous ends are brought into proper alignment with their corresponding stump on the elevated sternum by making a small osteotomy through the anterior cortex of each rib at its point of maximal anterior curvature (Figs.

164, c, and 165). Each of the cartilages is reunited with transfixion number 1 silk sutures.

A number 14 catheter is placed in the space beneath the sternum and brought out through the lower end of the wound so that suction may be applied for a few days to facilitate the shift of the mediastinum to its normal position and to prevent an accumulation of serum beneath the sternum. The wound is closed in layers without other type of drainage.

This procedure has produced perfect anatomical reformation of the anterior thorax. In addition, the convalescence has been smooth and has permitted early mobilization of the patient because of the great stability of the thorax accomplished by this technic. The mediastinal contents have returned immediately to their normal position, associated with amelioration of the patient's symptoms.

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TREATMENT OF PORTAL HYPERTENSION AND ASSOCIATED ACUTE HEMORRHAGE

HERBERT D. ADAMS

The clinical syndrome of splenomegaly, portal hypertension and associated recurrent serious gastrointestinal hemorrhage is not an uncommon problem that taxes the clinician's and surgeon's ingenuity and skill to the utmost, not only to tide these patients over these serious episodes of hemorrhage but to apply some form of specific therapy to prevent them.

ANATOMIC AND PHYSIOLOGIC CONSIDERATIONS

In order to understand the complex problems involved in the management of these conditions it is essential to have a knowledge of some of the basic anatomic and physiologic factors involved, especially of the portal system and associated structures. There are two capillary beds within the liver: (1) the portal system draining the intestinal tract, spleen, biliary tract and carrying approximately 75 per cent of the blood going to the liver plus the nutritive material from the intestine and the internal secretions of the pancreas, and (2) the collateral system composed of the capillary bed of the hepatic artery within the liver which transports the oxygen to the liver and by a very delicate pressure relationship with the portal system, controls the blood flow through the liver lobules. Likewise, in the basic understanding of the cause and treatment of portal hypertension it is important to remember that the portal system has no valves. This important anatomic detail has considerable bearing on the possibility of various venous shunts relieving the hypertension in this system. Portal hypertension is produced by either an intrahepatic or extrahepatic portal block. The best example of portal block is commonly seen in the syndrome of portal cirrhosis associated with congestive splenomegaly and frequently with hypersplenism as well. The intrahepatic pathologic condition is differentiated by evidence of reduced liver function as shown by the various liver function tests, such as bromsulphalein retention, reversed albumin-globulin ratio and abnormal flocculation tests. In most instances, however, it is not possible to determine accurately the site of the extrahepatic block clinically, and frequently this cannot be done even at operation.

Portal hypertension, that is a pressure within the portal system above the normal pressure of 8 to 10 mm. of mercury or 60 to 100 mm. of water, when established, produces extensive collateral communications with the systemic system, chiefly through the gastrocolic mesentery to the intercostals, coronary veins, both the gastrohepatic and gastrosplenic ligaments over the fundus of the stomach, the cardia of the stomach, the diaphragm and the esophagus into the azygos system and superior vena cava. The extent of this collateral and, therefore, the extent of the varicosities in the upper gastrointestinal tract depend on

Originally published in Surgical Clinics of North America, 31:803–812 (June) 1951.

the degree, the site and the type of this portal obstruction. The portal cirrhoses with intrahepatic block have an extremely variable clinical picture and, as mentioned before, are diagnosed largely on the basis of reduced liver function. The extrahepatic block may occur at any point in the portal system as a result of a sclerosing, fibrous replacement of varying lengths of portal veins from inflammatory processes, congenital anomalies, arteriovenous aneurysm, trauma or from obstruction due to neoplasms.

TREATMENT

Portal obstruction, either intrahepatic or extrahepatic, associated with congestive splenomegaly and acute gastrointestinal hemorrhages is the usual indication for surgical intervention. Before the fine contributions of Whipple and Blakemore, in 1945, to this particular problem, four methods of treatment were used: (1) splenectomy, (2) attempts to establish adequate collateral circulation by means of omentopexies of various types, (3) ligation of the venous channels about the cardia and esophagus and also packing of the para-esophageal mediastinal planes and (4) injection of the varices with sclerosing substances by means of the esophagoscope.

Since the spleen carries approximately 40 per cent of the portal circulation, a block restricted to the splenic vein, such as occurs occasionally in pancreatic trauma, inflammation or neoplasms of either the pancreas or the stomach and perhaps representing less than 5 per cent of all these cases, can be cured by splenectomy. The spleen in this instance represents a simple congestive splenomegaly due to the block in the splenic vein itself. In addition, even in a block in the main portal vein or liver, splenectomy may give temporary relief from the recurring hemorrhages. The other methods of treatment have likewise either been entirely ineffective or have given very temporary relief.

Although some isolated attempts were made to anastomose the portal and systemic systems since the original work of Eck in 1877, it remained for Whipple[5] and Blakemore[3,4] to work out a rational approach to this problem and to develop a specific technic for carrying out this surgical procedure. Blakemore's original operation was the nonsuture method using a vitallium tube for an end-to-side portacaval anastomosis and an end-to-end splenorenal anastomosis, removing the kidney. Since then there have been many other developments and a swing back to a simple suture type of anastomosis with preservation of the kidney.

Conservative Medical Measures. One of the most serious and immediate problems in the management of these cases is the treatment of the associated acute hemorrhagic phase. As in the more common massive hemorrhages associated with duodenal ulcer, a large proportion of these hemorrhages will be controlled by conservative medical measures. On this regimen, however, these patients must not be allowed to get into a stage of prolonged or profound shock before more specific measures are carried out. Esophagoscopy, injection with sclerosing materials of the presenting esophageal varices and even packing with oxycellulose have been effective to some extent in controlling some of the hemorrhaging tendencies to a lesser degree in these cases. In our experience with some of these patients, particularly those who continue to exsanguinate after conservative measures and blood replacement have been tried, and injections have failed to pro-

duce anything but very temporary cessation of the bleeding, we have found that the massive hemorrhage is not coming from the esophageal varices but from huge varices around the cardia and in the very top of the fundus of the stomach. We have tried inflating balloons within the stomach, pulling it back against the cardia and exerting continuous pressure in this manner both on the cardia and lower esophagus. This likewise has temporarily stopped hemorrhages in this type of severe hemorrhaging case, but to continue this for any period of time is extremely hard on a patient who is already greatly debilitated, chronically ill and on the verge of shock, and such patients have a great deal of difficulty in eliminat-

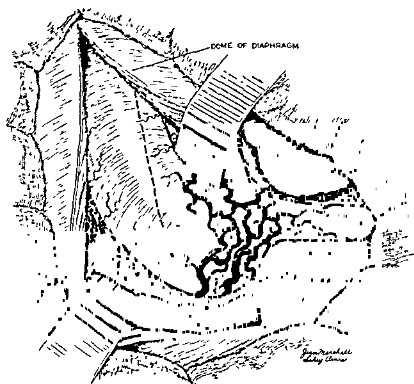


Fig. 166. Esophagogastric resection and splenectomy with splenorenal shunt for acute hemorrhage associated with portal hypertension. I. Abdominothoracic exposure of stomach, esophagus and spleen.

ing the secretions that collect in their pharynx. Such tubes must have a *triple* lumen so that suction, both intragastric and intra-esophageal, can be maintained *above* and *below* the inflated balloon if overflow into the lungs is to be prevented and such serious conditions as pneumonia and lung abscess are to be avoided in these cases. In some of these cases even this continuous pressure has only temporarily stopped these hemorrhages and in cases in which there have been large bleeding varices in the very top of the fundus as well, this method has not controlled this severe type of hemorrhage from such widespread varices throughout this area.

Abdominothoracic Resection of Lower End of Esophagus and Upper Half of Stomach with Splenectomy. Although the mortality will be high, as in the same problem of gastric resection for duodenal ulcer with uncontrollable, massive, acute hemorrhage, we have carried out abdominothoracic resection of the lower end of the esophagus and the upper half of the stomach with splenec-

tomy, and in some cases splenorenal shunt as well, with survival and good end results in a few selected cases in which all other measures mentioned have failed. We have, likewise, applied this procedure to patients who have previously had splenectomy in which the esophageal and cardial varicosities persist with asso-

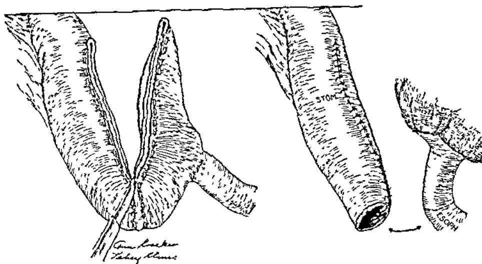


Fig. 167. Esophagogastric resection and splenectomy with splenorenal shunt. II. Technical details of resection of the proximal half of the stomach.

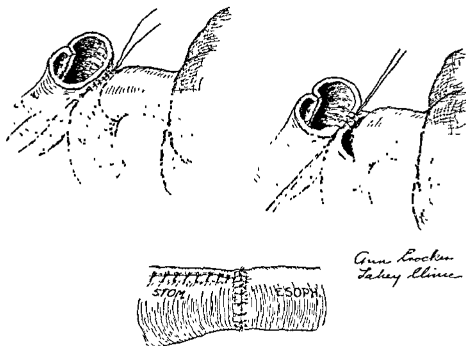


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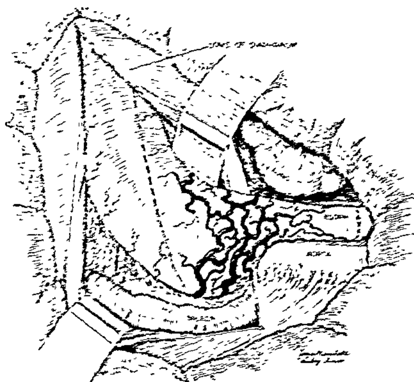


Fig. 166. Esophagogastric resection and splenectomy with splenorenal shunt for acute hemorrhage associated with portal hypertension. I. Abdominothoracic exposure of stomach, esophagus and spleen.

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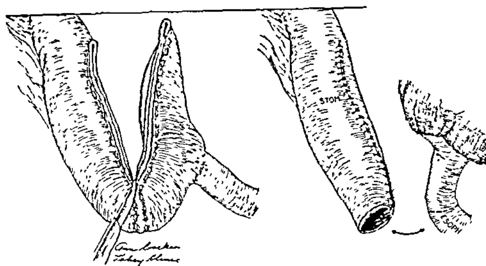


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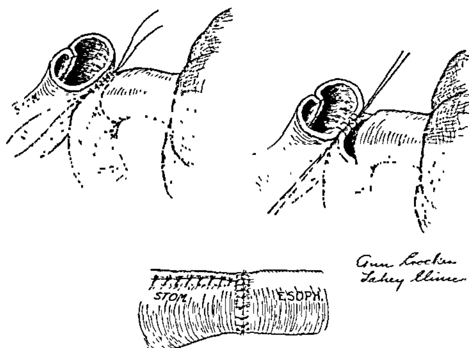


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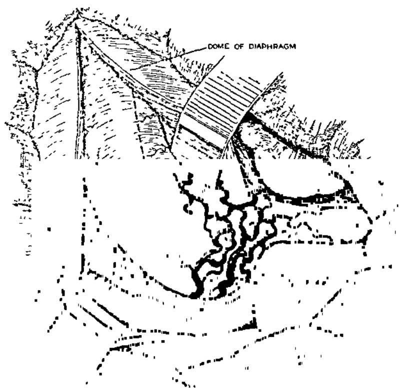


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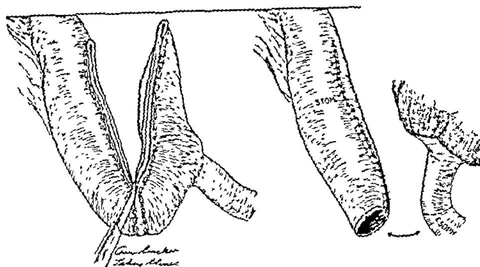


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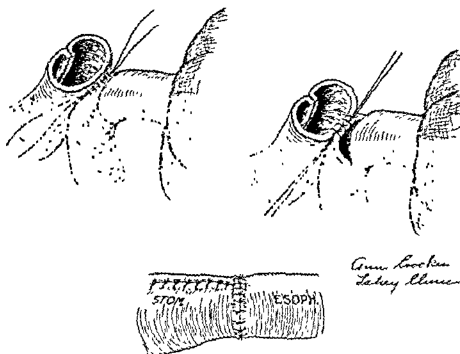


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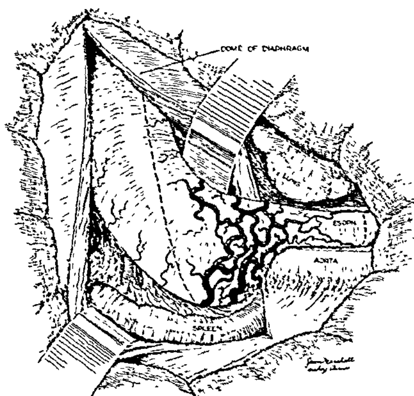


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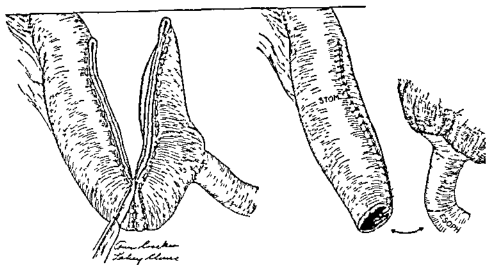


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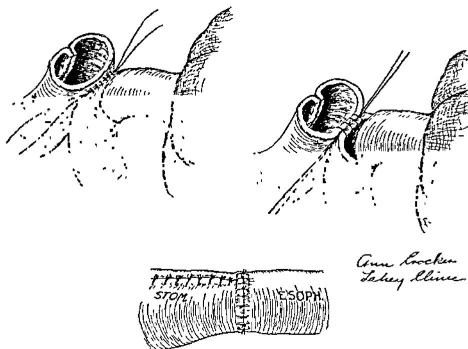


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Shunt Operations. In a large proportion of the bleeding cases, however, the

hemorrhage can be controlled by simple medical measures and, under these conditions, exploratory operations should be performed as elective procedures with the purpose of performing some type of shunt operation to reduce the portal hypertension and prevent subsequent and recurrent hemorrhages. All these patients should have careful preparation under medical supervision, attention to the liver function, blood chemistry, the blood volume and finally to the renal function. This latter should be very carefully determined by preoperative intravenous pyelograms, since it is possible that the left kidney might have to be removed or its function impaired by the various factors involved in establishing

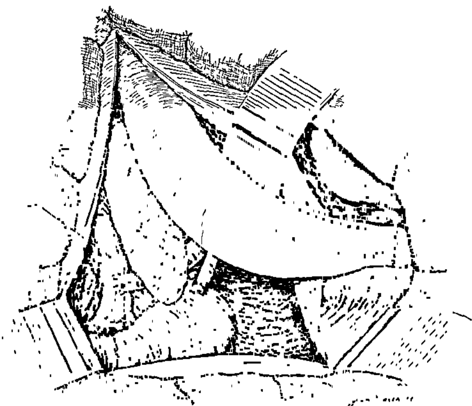


Fig. 169. Esophagogastric resection and splenectomy with splenorenal shunt. IV. Esophagogastric anastomosis completed. Splenectomy and splenorenal shunt carried out through the same exposure

a splenorenal shunt. The type of shunt used depends on what veins are available for a satisfactory anastomosis. This, in turn, depends on what previous procedures have been done, that is, whether splenectomy or other attempted shunts have been carried out, and upon the exact condition of the splenic and portal veins at the time they are exposed. These veins cannot be used if they are sclerosed or show extensive cavernous replacement, which is one of the commonest causes of failure in attempting to do portacaval shunts. We have, therefore, favored splenectomy and splenorenal shunt thereby simultaneously removing 30 or 40 per cent of the venous load on the portal system, as well as in a high percentage of cases being able to preserve a very satisfactory splenic vein for a splenorenal shunt, preserving the kidney.

We have used two types of incisions which have given very adequate exposure of these areas, either an abdoninothoracic incision or a long subcostal incision

crossing both rectus muscles midway between the xiphoid and the umbilicus, continuing around either to the right or left, depending on whether a portacaval or splenorenal shunt was anticipated, carrying the subcostal extension around posteriorly to the tip of the twelfth rib. Either the abdominothoracic or this subcostal transverse incision will give excellent exposure of both areas.

As already stated, generally the most satisfactory shunt from all aspects is the *splenorenal shunt*, the spleen being removed, carefully preserving as much of the splenic vein stump as possible. In dissecting the splenic vein or attempting to develop a longer stump, one must be extremely careful in mobilizing it from its bed in the pancreas since there are many small pancreatic communications which must be ligated with extreme care in order not to tear the portion of the splenic vein that is to be utilized in the shunt. Before the spleen is removed, however, the pressure should be taken in the portal system with a manometer. Usually one of the varicosities in the gastrocolic ligament will be satisfactory to demonstrate the degree of portal hypertension. This is essential since no shunt can be expected to function or remain patent if the venous pressure within the portal system is not definitely increased. Once the splenic stump has been satisfactorily developed and the spleen removed, the structures of the kidney pedicle must be then carefully cleared of perirenal fat and identified, again using great care not to tear the vein during its mobilization and the ligation of any small tributaries. The accepted method of controlling the renal pedicle is to apply a rubber-covered bulldog clamp to the renal artery and isolate a segment of the renal vein by the application of encircling traction sutures of heavy silk.

It has been our experience that the time required to carry out a satisfactory suture type of end-to-side anastomosis is roughly thirty to forty-five minutes and we were interested to note whether or not shutting off the renal artery for this length of time would produce any appreciable permanent damage to the kidney. It was our immediate impression that it might be better to accept prolonged congestion as being safer than prolonged ischemia and that it might, therefore, be safer to leave the artery unclamped, shutting off the vein only during this length of time. Two parallel series were carried out to test out these theories, half of them done in the standard way by clamping the artery and the vein and the other half by shutting off the vein only. Preoperative intravenous pyelography was carried out and this was repeated in the immediate postoperative period during the hospitalization. There were a number of instances of definitely reduced renal function in those cases in which the artery as well as the vein was clamped off and there were no instances in the cases in which only the vein was shut off during the anastomosis, which confirmed our original belief that it was safer to accept prolonged venous congestion of the kidney than prolonged ischemia as far as the kidney function was concerned. Actually, *the ideal way* to carry out the shunt would be to allow the artery to be opened during anastomosis and the vein controlled with a small Pott's clamp so that an end-to-side anastomosis could be carried out without totally occluding the renal vein during the anastomosis. Many of these veins, however, are not suitable for the application of this clamp and, as stated before, we have found that shutting off the vein during this procedure has not to date resulted in any appreciable renal damage. No matter which method is utilized in controlling the splenic and renal veins

during the anastomosis, the actual detail of performing the anastomosis is carried out with a single row suture method, using two simple running fine silk sutures, each covering only half the circumference of the anastomosis, in order to prevent a narrowing purse-string effect of a single suture.

In all cases we believe that drainage of the splenic bed and left subdiaphragmatic space is essential. In spite of prophylactic use of antibiotics, residual abscess develops in some of these cases. This is due to the greatly lowered general resistance of these patients, and the fact that with congestive splenomegaly it is almost impossible to remove these large adherent spleens and attain absolute hemostasis in the vascular splenic bed. Likewise, it is impossible not to open up

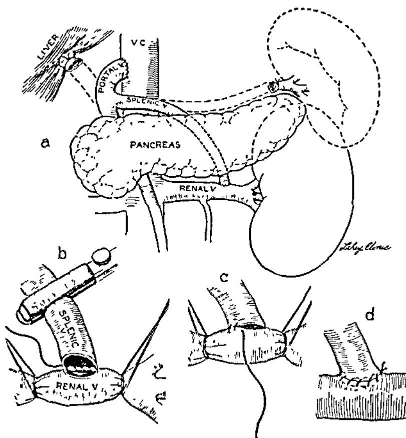


Fig. 170. Details of suture method of splenorenal shunt.

some pancreatic tissue incorporated in the hilus, so that even the smallest amount of free pancreatic secretion and hematoma in the splenic bed and left subdiaphragmatic space forms an ideal culture medium. Under these conditions antibiotic coverage will not prevent formation of an abscess in this region which will eventually require secondary drainage. We, therefore, routinely drain the left subdiaphragmatic space, bringing the cigarette drain out subcostally in the flank, either in the outer end of the subcostal incision or through a stab wound if an abdominothoracic incision has been used.

Portacaval shunts have been carried out through a right abdominothoracic or right subcostal incision doing an end-to-side anastomosis by the suture method. As already stated, however, there has been a higher percentage of failures be-

cause of a greater tendency to find a cavernous replacement or hemangiomatous type of collateral in this area which makes it impossible to develop a suitable portal stump for anastomosis. In some cases in which a previous splenectomy had been performed or in which there have been previous attempts at shunt operations with failure and continued recurrent hemorrhages, attempts can be made with other radicals of the portal system, such as the superior mesenteric to the inferior vena cava, end-to-side, or the inferior mesenteric to the ovarian or spermatic, or to the renal systemic veins. When one attempts anastomosing vessels of this caliber, however, it is very probable that they do not remain patent, and we have come more and more to favor resection of the upper stomach and lower esophagus under these circumstances.

The most common indication for a shunt procedure is congestive splenomegaly with either an associated intrahepatic or extrahepatic block and recurrent gastrointestinal hemorrhages. These patients should definitely have a splenectomy and a splenorenal shunt carried out. We have now reached a point, with no operative mortality to date, that our medical department wishes us to operate upon all patients with any appreciable splenomegaly with a presumptive diagnosis of congestive splenomegaly and question of portal hypertension clinically. The pressure of the portal system is determined before removal of the spleen, and if it is elevated well above normal, we do a splenorenal shunt. By doing this early it is their opinion that it may be possible to prevent the further development of esophageal varices and subsequent hemorrhages. Up to the present time we have not utilized any of the methods devised to determine patency of the splenorenal shunts after operation, but have depended chiefly on the clinical improvement of the patient and the cessation of hemorrhages to indicate a satisfactory result.

We have made one other interesting observation with reference to the fact that the roentgenographic studies of the esophagus in patients who have had a satisfactory shunt opration and who have had no further clinical symptoms and no further recurrence of the gastrointestinal hemorrhages, consistently show persistent evidence of no appreciable regression of their esophageal varices after these procedures. The fact that they do not have recurrent hemorrhage must indicate a reduced pressure within these persistent varices. Once established, however, they may be kept in their state of partial dilatation because of the normal presence of arteriovenous shunts within the stomach wall, which have been demonstrated by Professor Bentley of England. This added factor in maintaining an increased venous pressure in this region would seem to be another reason for gastro-esophageal resection in resistant cases.

SUMMARY

Portal hypertension with associated recurrent upper gastrointestinal hemorrhages should be treated electively by establishing a shunt, *preferably* a splenorenal shunt.

The acute serious hemorrhaging phase may be controlled by conservative measures, injections and balloon pressure. If the measures fail to be *effective*, abdominothoracic esophagogastric resection, splenectomy and splenorenal shunt should be carried out.

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THE STOMACH AND DUODENUM

THE SURGICAL TREATMENT OF DIAPHRAGMATIC HERNIA

Clinical Report of 73 Cases

DAVID P. BOYD AND JOHN N. CLASSEN

Although the first description of a diaphragmatic hernia appeared in the sixteenth century, the condition remained more or less a medical curiosity for three hundred years. The development of the roentgen ray and its utilization with a barium mixture to cast a shadow of the gastrointestinal tract made a definite medical diagnosis of this condition possible. The number of cases in which the disease was reported remained small, however, until Ritvo[1] in 1930 suggested the Trendelenburg position to demonstrate a diaphragmatic defect. Thus the number of times this lesion was recognized has increased steadily, until now it is the second most frequent pathologic condition encountered in a large series of gastrointestinal cases, duodenal ulcer being the most common.

The literature has kept pace with our increasing familiarity with the condition and is replete with excellent articles giving classifications and considerations of anatomy and embryology. Others relate clinical manifestations. There have been reviews of large series of patients treated both medically and surgically. In spite of the wealth of material on this subject, however, we have thought that several pertinent questions were not answered, and thus undertook the following study.

It has been our impression at the clinic that the operative results have been superior when the repair has been done by the transthoracic route. We wished to substantiate this if possible. Secondly, we wished to investigate the correlation between clinical and x-ray recurrences, that is, what percentage of people had recurrences demonstrated in the roentgenogram and how many of these had symptoms, and how many had persistent symptoms without demonstrable recurrence.

In undertaking such a study it was our aim to have as many as possible of the 73 patients return to the clinic for a barium study and re-evaluation. Failing this, we sent them a questionnaire to be returned for study. We wished to know whether they were free of symptoms, whether they had had a roentgenologic examination since operation, and whether they had had any subsequent surgical procedure In spite of only moderate success in our follow-up, this study reveals some facts which are interesting and are the basis for forming our opinions, although they cannot be considered statistically significant facts.

This series includes 73 patients with diaphragmatic hernia referred to surgery between the years 1928 and 1949 (Table 1). Thirty-eight of these have been treated since 1945. This is important as it gives one an idea of the increasing frequency with which the diagnosis is being made.

Originally published in Surgical Clinics of North America, 31:813–822 (June) 1951.

In a breakdown of the cases, 10 were found to be of the traumatic variety. Nine were males and gave a history of having been subjected to severe trauma. In this group, pain was the most frequent symptom, while belching, vomiting and dysphagia occurred in that order.

Table 1. Type of Hernia

	CASES
Hiatus hernia	50
Traumatic	10
Space of Morgagni	9
* ? Foramen of Bochdalek	4
Total	73

* Records not clear—may perhaps represent cases of congenital absence or complete attenuation of the left crus.

There were 9 patients with hernias through the space of Morgagni. Eight of the patients were women. As in all groups, pain was the most common symptom.

Forty-three out of 50 esophageal hiatus hernias appeared in females. Of the total number of 50 patients with esophageal hiatus hernias, 44 had moderate to

Table 2. Symptoms in 50 Cases of Hiatus Hernia

	CASES	PER CENT
Pain	44	88
Vomiting	20	40
Gross bleeding	14	28
Anemia	11	22
Asymptomatic	7	14
Obesity	38	77

severe pain, 20 gave a history of vomiting, 14 had bleeding severe enough to be recognized grossly, 11 others were found to be anemic, while 38 were obese (Table 2).

Table 3. Associated Upper Abdominal Disease

	CASES	PER CENT
Biliary Tract Disease		
Confirmed by x-rays or operation	19	38
Not present	15	30
Not indicated	16	32
Duodenal Ulcer	2	4

Nineteen of this group were found to have a coincident pathology (Table 3), notably gallbladder disease, either by exploration or by positive roentgenograms. In 15 cases the gallbladder was found free of diseases by these methods and in

16 cases no mention was made of this organ. In the traumatic group, only one patient gave a history of gallbladder disease, and to our surprise we were able to find only 2 instances of a confirmed diagnosis of duodenal or gastric ulcer, although this type of disease was strongly suspected in others.

It is of interest to ascertain the number of patients in this series of 73 who were asymptomatic. Seven patients sought treatment only because routine roentgenologic examination revealed pathologic conditions in the chest. Four of the 7 had hernias of the hiatal variety, while 3 had protrusions through the space of Morgagni.

We were particularly interested in postoperative complications with special reference to determining with which approach the mortality and the incidence of serious complications were less (Table 4). Five patients had postoperative

Table 4. Results of Transthoracic Repair in 24 Cases

		CASES
Deaths		0
Followed		15
X-rayed		11
Recurrences		4
Large	0	
Small	4	
Symptoms		3
Serious stricture	1	
Bloating, heartburn	2	
Thrombophlebitis		1
Empyema		3

strictures of the esophagus; 4 responded to conservative treatment, including dilatation and diet, and are now considered cured, while the fifth required surgery and plastic repair. Empyema developed in 3 patients, but in no case in recent years. In one of the 3 patients, however, the empyema occurred four years after operation; the patient had been completely asymptomatic during the interim. It responded to simple drainage. In three instances a collection of pleural fluid required drainage. One patient had a severe thrombophlebitis. One man died nine months after operation from a carcinoma arising in the left lung. This was particularly distressing since the hernia was repaired through the left thorax. This tumor may have been present at the time of the operation upon the diaphragm. This death impresses one with the fact that thorough routine exploration is just as essential in the chest as it is in the abdomen.

There were 3 postoperative deaths, all occurring in patients who had transabdominal repairs (Table 5). One death was caused by a pulmonary embolism and 2 by cardiac failure. One patient of the latter group had become jaundiced; pancreatitis had developed and evisceration occurred before cardiac failure took place. When the reasons for death are closely examined, no statistical significance can be placed upon the fact that all 3 occurred in patients whose hernia was repaired through the abdomen.

Results of Follow-up Studies. In 24 cases the repair was made through the thorax. Follow-up studies ranged from nine months to eight years on 15 of

these 24. Eleven of the 15 were checked by roentgenograms and 4 recurrences were seen. All of these recurrences were designated as small by the radiologist. In going over the instances in which a recurrence was found we learned that 3 of these 4 patients had symptoms. One man suffered from a stricture which responded to dilatation. A second had heartburn of sufficient degree to be a problem to him, while a third was troubled with fullness, bloating and occasional vomiting.

Of 49 cases of transabdominal herniorrhaphies, 36 were followed from nine months to twenty years. Of these 36, 15 patients were examined roentgenologically and 7 recurrences were found. Of the 7 patients with recurrences, 4 had symptoms, and one with no evidence of recurrence on the roentgenogram had mild pain in the anterior chest. Two of this group with evidence of recurrence

Table 5. Results of Abdominal Repair

		CASES
Total number		49
Deaths		3
Pulmonary embolism	1	
Pancreatitis, evisceration, heart failure	1	
Heart failure	1	
Followed		36
X-rayed		15
Recurrences		7
Recurrences with symptoms		4
Operations for severe symptoms (transthoracic)		2

had symptoms of sufficient severity to come to secondary repair. This was done by the transthoracic route and these 2 patients have subsequently been symptom free.

Conclusions. Patients who have diaphragmatic hernias with significant upper abdominal symptoms should have careful gastrointestinal study to rule out concomitant disease. This series shows that most frequently this pathologic change will be in the biliary tract, but peptic ulcer, carcinoma of the stomach and carcinoma of the colon should be carefully ruled out.

There is a high correlation between clinical recurrences (symptoms) and x-ray recurrences.

The results of this study corroborate the impression at the clinic that the recurrence rate, morbidity and mortality are lower when transthoracic repair is performed for a diaphragmatic hernia.

In some cases (2 in this group), it is technically impossible to repair the hernia adequately from below the diaphragm. In such cases a second operation is, of course, mandatory.

Because of these considerations, it is thought at the present time that all diaphragmatic hernias which are of sufficient size to cause significant symptoms should be repaired by the transthoracic route. As in all series of cases covering a period of twenty years, considerable improvement is noted in the more recent statistics. It is suggested that transthoracic herniorrhaphy can be done in the future with very little morbidity and a high cure rate.

SPECIAL CONSIDERATIONS

Before discussing some of the technical problems associated with the repair of herniations through the diaphragm, it should be emphasized that there are many cases of diaphragmatic hernia which do not require surgical treatment. These include patients who have small sacs without symptoms and older or poor risk patients with minimal or only moderate symptoms. Although the operation of phrenicectomy leaves much to be desired in treating this condition, it has a certain definite field of usefulness in the older and poor risk group. In fact, personal experience with the phrenic operation suggests that it is much more effective than the literature would indicate. It is probably not advisable to perform the operation of permanent phrenic crush if there is any prospect that repair of the diaphragm may subsequently be necessary. If the hernia is of significant size and particularly if the symptoms are marked, however, transthoracic repair should be carried out because of the very real incidence of complications of diaphragmatic hernia.

We have had a number of patients admitted to hospital with acute incarceration of a hiatus hernia and obstruction of the antrum of the stomach. One such patient was in severe electrolyte imbalance from gastric obstruction and upon introducing a Levin tube into the stomach, 2,000 cc. of fluid was withdrawn. In the course of forty-eight hours of continuous aspiration, the antrum of the stomach was reduced into the abdomen, thereby relieving the obstruction. Elective transthoracic repair was carried out several days later after the fluid balance had been completely restored.

We have recently performed a transthoracic repair of a small diaphragmatic hernia in a patient who had spent six weeks in hospital following a massive gastrointestinal hemorrhage. This was thought to be due to a duodenal ulcer but subsequent films showed the duodenum to be perfectly normal.

Repair of a diaphragmatic hernia was carried out on a vigorous consulting engineer who had one symptom only, that of increasing fatigue. This patient was one of a minority of males in the series. A strong and vigorous man who had no sign of anxiety of any sort, his fatigue was completely incomprehensible to him. Examination revealed that this patient had a diaphragmatic hernia through the hiatus and a hemoglobin of 7 gm. He has been completely well since his repair. The importance of looking for a diaphragmatic hernia in all cases of obscure gastrointestinal bleeding is apparent from these cases.

Preoperative Preparation of Patients. It is our habit and our preference to have all patients with diaphragmatic hernia esophagoscoped before operation. This helps to rule out the occasional patient with a truly short esophagus and also serves to rule out the presence of esophagitis, cardiospasm or carcinoma of the lower esophagus. Patients who do not have obstruction require very little preoperative preparation. It is, of course, essential to be certain that the hemoglobin is at a normal level. A Levin tube is passed into the stomach in all cases of hiatus hernia. This not only achieves an empty stomach, which is easier to manipulate, but also permits one immediately to locate the esophagus in the mediastinum, which may actually be difficult if the sac is large.

The Operation. *Posture and Incision.* The patient is placed on the right side, with the table slightly arched so as to widen the intercostal spaces, and the

left arm is elevated to raise the angle of the scapula. It is then possible by making a long incision to resect the entire length of the eighth rib from the costal

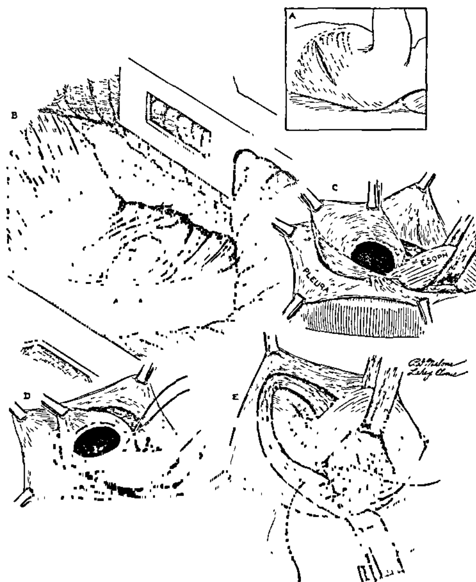


Fig. 171. *A*, This is the position employed when a thoraco-abdominal exposure is contemplated as in recurrent or very large hernias. As a rule the position of the patient is closer to the true lateral.

B, The bulging sac is apparent as it elevates the parietal pleura and splits the pulmonary ligament. A larger component may well extend into the right hemithorax.

C, This shows the opened sac fading off onto the cardia in the case of a reduced paraesophageal hernia.

D, Reduction is maintained by a ribbon retractor (not shown) while a purse-string suture is placed at the ring. Subsequent to this the excess peritoneum is trimmed off.

E, The crura have been freshened and the esophagus allowed to settle into its natural location In this case sutures were placed in the hiatus on both sides of the esophagus. We have preferred not to include the stomach wall in these sutures. If the left crus is at all attenuated the direction of the suture line may be more transverse than indicated.

cartilage to the transverse process. A small piece of the ninth rib is then removed and the chest is widely opened with a spreader over a period of several minutes. In case it should be necessary or desirable, this incision may easily be extended

down over the abdomen to convert the field into a thoraco-abdominal. At this point the importance of performing a careful exploration of the left chest, carefully examining each lobe of the lung and the mediastinal structures, is again emphasized.

Dissection of the Sac. In the large hernias, the sac will present between the pericardium and the aorta as a yellowish fatty mass overlaid by thin glistening pleura and pulmonary ligament containing a few tiny blood vessels. The esophagus may not be readily apparent. The esophageal hiatus may be only moderately enlarged, although the sac and the herniation may be very large. When this is the case the sac will have crossed the vertebral column into the right side of the chest and the right mediastinal pleura will be draped around it as a membrane. The first step is to crush the phrenic nerve lightly with a fine hemostat between the point where it leaves the pericardium and the point at which it enters the diaphragmatic muscle. This will reduce the excursion so that it is possible to work on the diaphragm. Furthermore, it will keep it at rest during the period of repair. It is, of course, undesirable to have a paralyzed diaphragm in this type of patient but it is essential to the success of the operation. The next step is to open the left mediastinal pleura longitudinally to identify the esophagus. The presence of an indwelling tube makes this readily possible. Many of these patients are women and very many of them are obese. The esophagus is usually small and very friable. Its musculature is extremely poorly developed and the organ must be handled with the greatest care. This cannot be overemphasized. If care is not used in dissecting the esophagus, the surgeon may find to his chagrin that the esophagus has been sufficiently traumatized to require resection. This happened in one recurrent case in this group. The greatest care, then, is used in mobilizing the esophagus from the neighboring mediastinal structures. The esophagus is followed down into the sac. It will then be possible to ascertain upon which side of the esophagus the sac ascends up into the mediastinum. When this has been decided, the sac may be opened, usually anterior or medial to the esophagus. The sac should be completely opened and treated like any other hernial sac, that is, it should be removed. These hernias are often of the sliding variety, that is, one side of the organ is not covered by peritoneum. This will usually be the cardia and the beginning of the greater curvature of the stomach. It is essential to bear this in mind in order not to injure the fundus of the stomach, the vasa brevia and the spleen.

After the sac has been opened and the contents reduced into the abdomen and held there with a ribbon retractor, the sac can be trimmed down to the margins of the hiatus. Interrupted sutures of medium silk are used to close the sac. It is then only necessary to repair the esophageal hiatus. As a rule, the defect in the diaphragm which comprises the abnormally large hiatus will have an elliptical appearance and will pass in the general direction of the 5 o'clock to 10 o'clock positions. When this is the case, it is as a rule relatively simple to maintain the reduction of the sac and contents and freshen the edges of the crura. They may then be overlapped with two layers of interrupted silk sutures. It is well not to place the esophagus in an eccentric position, but rather to attempt to replace it in its bed and suture the crura on either side of the esophagus rather than place

all the sutures on one or the other side. After placement of the final sutures, one finger should readily pass alongside the esophagus through the hiatus.

In an occasional case the sac and its contents are so large and the crura so attenuated that it is not possible to repair the crura carefully and deliberately. It is in these cases that an abdominal extension of the thoracic wound will be serviceable. By so doing and using the above and below approach, two good layers of sutures can usually be placed in the crura. At times, furthermore, the crura will be so thinned out, particularly on the left side of the defect, that there is practically no tissue between the spine and the aorta. This may present a difficult problem in repair somewhat similar to the difficulties encountered in hernias through the foramen of Bochdalek. We have not seen any case, however, in which it has been impossible to find sufficient tissue posteriorly to reunite the crura of the diaphragm when the operation was being performed for the first time.

On the contrary, in recurrent hernias and large hernias of the traumatic variety, it may be impossible, even with crushing of the phrenic nerve, to reunite the diaphragm. In these situations two alternatives are available. In the first place, fascia lata may be employed to bridge the defect, either as a sheet removed from the patient's thigh at the time of operation and used as a plaque or patch on the defect and tacked down with silk sutures, or by using a fascial suture after the Gallie principle. In cases in which there is complete absence of tissue posteriorly, a lower three rib thoracoplasty may be carried out so that the chest wall and the diaphragm may be approximated without tension.

The diaphragm should be carefully pleuralized but the mediastinal space where the sac existed should not be closed. On the contrary, it should be permitted to drain freely into the left pleural cavity, which in turn is drained by continuous under-water drainage. The chest is closed carefully using fine chromic catgut sutures.

Postoperative Care. A fine plastic tube is kept in the stomach for several days if pulmonary complications do not ensue. We consider this to be of great importance in order to keep the stomach deflated, thereby keeping tension off the diaphragm. Although every effort is made to spare the vagus nerves, some vagotomy effect may be encountered, and a dilated stomach is a troublesome complication in the early convalescence. The patient is watched very carefully for atelectasis, particularly of the left lower lobe. This is exceedingly difficult to prevent and postoperative pulmonary complications are difficult to evaluate. We have found bedside roentgenograms after diaphragmatic hernia operations to be singularly deceptive. If the hernia was large, there will be a large space in the mediastinum representing the area of dissection. These patients are obese; they have a small lung volume and frequently a small bony thorax. In addition the phrenic nerve has been crushed. All these factors tend to confuse the interpretation of postoperative roentgenograms. Accordingly, we have learned that we can place much more reliance upon postoperative physical signs. Many times a roentgenogram of a patient a day or two after such an operation has suggested to us the need for aspiration of the chest, whereas no fluid really existed. The presence of good breath sounds is the important consideration. If the patient can be encour-

aged to cough and the left lung can be re-expanded quickly, convalescence will be smooth.

HERNIAS THROUGH THE SPACE OF MORGAGNI

This is a confusing lesion and several of these 9 patients have been sent to us with the diagnosis of mediastinal or pulmonary tumors and, indeed, exploratory operations have been performed at the clinic on one or two of them with that diagnosis. On the other hand, 2 cases in this series were found as part of a routine abdominal exploration for other pathologic conditions. These hernias are easily repaired through the abdomen, and if the diagnosis can be assured, this is the approach of choice. They are frequently on the right side of the midline and represent failure of the anterior subcostosternal attachments of the diaphragm to the seventh costal cartilage. Closure of the defect is usually easily carried out, either from above or below, by placing two rows of sutures between the musculotendinous anterior portion of the diaphragm and the intercostal musculature and the actual cartilage of the seventh rib. There have been no recurrences in the 9 cases herewith reported.

CONCLUSIONS

Inasmuch as it is thought at the present time that transthoracic repair is the method of choice in all cases of diaphragmatic hernias except those through the foramen of Morgagni, a detailed account of the technic is given. Occasionally, in very large hernias or in recurrent diaphragmatic hernias, the combined thoraco-abdominal approach with the use of fascia lata may be required.

REFERENCE

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GASTRIC ULCER: A STUDY OF 600 CASES

FRANCES H. SMITH AND SARA M. JORDAN

INTRODUCTION

An estimated incidence of 80,000 cases of gastric cancer in this country, with a death rate of 40,000 per year, is indeed an effective spur to the adoption of any prophylactic or therapeutic measure by which this afflictive evil can be combated. That a certain percentage of these cases have their origin, as a wolf in sheep's clothing, in the form of gastric ulcer, there is now no doubt. In the estimation of our pathologist they constitute 20 per cent or less of the total group of cancer of the stomach. In contrast to the other three groups of manifestly malignant lesions—the polypoid lesion which protrudes into the lumen, the obviously ulcerating carcinoma, usually with only one side definitely bordered, or the diffusely infiltrating lesion—this group of cases which look like ulcer can reasonably be thought to be benign. Yet, either from their beginnings on they are not benign, or they change from a once benign character to a later malignant one.

Differentiation between benign and malignant gastric ulcer, with all the diagnostic and therapeutic problems involved in this issue, should excite investigation, contemplation and reasoned judgment, and first of all, investigation, because it alone is the logical precursor of meditation and reasoned judgment. In the spirit of investigation of this problem, therefore, this study of 600 cases of gastric ulcer was undertaken.

In an earnest search for the greatest therapeutic good for the greatest number of patients, one is confronted with the question: Is the situation so perilous that all patients with gastric ulcers shall be submitted to gastric resecion and the differentiation between benign and malignant lesions be left to the pathologist? Or, on the other hand, shall gastroenterologists continue their attempts to distinguish between those gastric ulcers which can be trusted to be benign, and those which are or may become malignant? This issue is of tremendous importance even in these days when, with the advance of skill in surgery and anesthesia, the risk of resection has markedly decreased. An established and generally accepted policy of resection of all gastric ulcers means that throughout the country, wherever surgery is done, benign ulcers, if on the proximal side of the pylorus, will be resected. As a result of this policy, a certain number of individuals with benign ulcers which would have healed under medical treatment will have died as a result of the operation, and a relatively large number of persons will be living with the physiologic abnormality of having only one-third or less of their stomachs.

Considered judgment and not snap decision is required. In this regard it may not be amiss to call attention to the very human frailty, of which most of us are guilty, of being swayed in our judgment by our last or most striking experience.

Originally published in Gastroenterology, *11* 575–593 (Nov.) 1948.

An ulcer treated too long as benign and later found to be inoperable or in a late stage of malignancy makes a poignant and unforgettable impression upon all concerned; but no less keen is the impact upon memory and medical conscience of the patient with ulcer histologically proved benign, who has died right after resection of the stomach. We must also be prepared to confront the physiologic and functional disorders which may to some degree, at least, follow resection—justified most certainly if malignancy, actual or potential, or intractability has existed, but equally certainly regrettable if this is not the case.

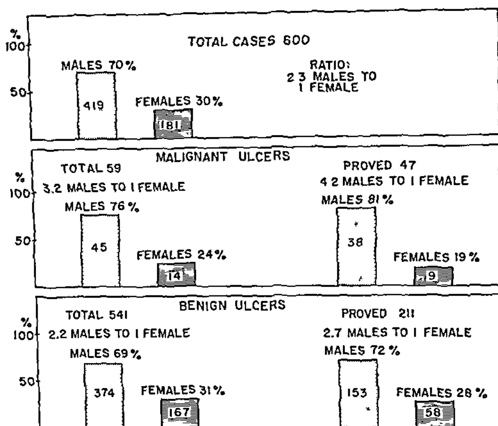


Fig 172. Sex incidence.

Before suggesting a possible solution to the problem outlined, we wish to present the statistical data obtained in this study of 600 cases. This material is presented in four categories: first, the malignant ulcers; second, the benign operated ulcers, third, the benign nonoperated ulcers and fourth, a comparison of the findings in the benign and malignant groups.

Figure 172 gives the sex incidence for the entire group, the total benign and the total malignant group as well as that in the proved benign and proved malignant cases. Here it is of interest to note that whereas the total group and the proved benign group show a preponderance of males in the ratio of approximately 2 males to 1 female, the proved malignant group shows the ratio to be 4 males to 1 female, or almost twice as much.

MALIGNANT ULCERS—59 CASES

The incidence of malignant gastric ulcers in the entire group was 9.8 per cent. Table 1 shows that 47 of these 59 cases were histologically proved and that 12,

although clinically considered to be malignant, were not operated on for the reasons stated.

Table 1. Analysis of 59 Malignant Ulcers

44	operated on and proved pathologically
12	not operated on because of refusal, age or concomitant disease but clinically presumed to be malignant
2	treated as benign but proved at postmortem examination (6 and 23 years later) to be malignant
1	diagnosed as malignant, refused operation, and proved by postmortem examination to be malignant

Table 2 shows the number and type of operations performed. It is important to note that in only 75 per cent of the patients with malignant gastric ulcers was the lesion resectable at the time of operation.

Table 2. Analysis of 44 Operated Malignant Ulcers: Type of Operation

	NUMBER OF CASES
Total gastrectomy*	2
Partial gastrectomy*	31
Laparotomy	8
Gastrostomy	1
Anterior jejunostomy	1
Suture of perforation	1

* Resectability rate, 75 per cent.

Table 3 lists original diagnoses after the initial clinical and roentgenologic survey had been completed.

Table 3. Analysis of 44 Operated Malignant Ulcers: Original Diagnosis

	CASES	
	Number	Per cent
Malignant	21	47.8
Benign*	23	52 2

* 50 per cent of these patients later operated on because of recurrence.

Table 4 gives the length of follow-up preceding operation. Fifty-four and five-tenths per cent of the patients with malignant gastric ulcers were operated on

Table 4. Analysis of 44 Operated Malignant Ulcers Length of Follow-up Preceding Operation

DURATION	NUMBER OF CASES	
1 month or less	17	54.5%
1 to 2 months	7	
2 to 4 months	5	
4 to 6 months	5	
6 to 12 months	1	
1 to 2 years	2	
2 to 5 years	5	
5 to 7 years	2	

within two months from the time they were first seen at the Lahey Clinic. The others were operated on at intervals varying from two months to seven years. Of the 5 patients who were not operated upon until two to four months after they were first seen, two patients refused immediate hospitalization. Two were the victims of delayed hospitalization and one was operated on because of persistence of symptoms although no lesion had been demonstrated by roentgenogram before operation.

Of the 5 patients whose operations were delayed four to six months, 1 patient did not return for roentgenograms for four months; 2 were operated upon because of persistence of symptoms and 2, although all clinical and roentgenologic signs of ulcer disappeared after treatment, because of recurrence.

*Table 5. Analysis of 44 Operated Malignant Ulcers: Mortality Statistics**

	CASES		
	Number	Per cent	CAUSE OF DEATH
Total hospital mortality	5	11.1	Coronary disease .... 2 Carcinomatosis 1
Total operative mortality	2	4.5	Pulmonary embolus ...... 1 Peritonitis 1

* *No death occurred in resected cases.*

The 10 patients operated upon later than six months had had medical management in or out of the hospital and were operated upon because of recurrence.

Table 5 gives the mortality statistics in the 44 cases of operated malignant ulcers. None of these deaths occurred after resection; 4 followed laparotomy and 1 the suture of a perforation.

Table 6 gives the survival period in the 33 patients with malignant ulcer who had gastric resection. Only 5 of this group, or 15.1 per cent, were alive after five years One of these patients who was found to have a lymphosarcoma at operation was alive and well nine years later.

Table 6. Analysis of 44 Operated Malignant Ulcers: Survival Period of 33 Resectable Cases

	CASES	
DURATION	Number	Per cent
2 years postoperatively	19	57.5
5 years postoperatively*	5	15.1

* 1 patient was alive and well nine years after operation for lymphosarcoma.

BENIGN OPERATED GASTRIC ULCERS—*211 CASES*

The group of 541 benign ulcers is subdivided in our study into 330 cases treated medically and proved benign only by the patient's clinical course and roentgen findings, and those 211 cases proved benign by pathologic examination after resection.

Of the 211 patients with benign ulcer who had a resection 3 had total gastrectomy and 208 had partial gastrectomy (Table 7).

The indications for operation are given in Table 8. From this it may be seen

that 89 patients, or 42.1 per cent, of this group of 211 were operated on because of the diagnosis of malignancy or because malignancy was strongly suspected. Seventy or 33.1 per cent were resected because of recurrence, 21 or 9.9 per cent because of failure to heal, 29 or 13.7 per cent because of complications. One

Table 7. Analysis of 541 Benign Cases: Treatment of Cases

	CASES
Operated	211
Total gastrectomy	3
Partial gastrectomy	208
Nonoperated	330

patient had a gastric polyp and in 1 a large gastric ulcer which had not been discovered at roentgenologic examination was found when the patient was operated on for cholelithiasis.

Table 8. Analysis of 211 Operated Benign Ulcers: Indications for Operation

	CASES	
Diagnosis of carcinoma	15	42.1%
Diagnosis of probable carcinoma	74	
Recurrence	70	33.1%
Obstruction	17	13.7%
Hemorrhage	3	
Intractability	9	
Failure to heal	21	9.9%
Polyp	1	
Planned cholecystectomy (large ulcer incidental finding)	1	

Table 9 shows the length of follow-up preceding operation in the 211 patients with benign gastric ulcer. One hundred forty-one, or 66.8 per cent, of the patients were operated on within two months after they were seen at the Lahey Clinic. The others underwent resection at intervals varying from two months to eleven

Table 9. Analysis of 211 Operated Benign Ulcers: Length of Follow-up Preceding Operation

DURATION	NUMBER OF CASES	
1 month or less	115	66.8%
1 to 2 months	26	
2 to 4 months	12	
4 to 6 months	10	
6 to 12 months	11	
1 to 2 years	6	
2 to 11½ years	31	

and a half years. As in the malignant group, the majority of these patients under medical management either in or out of the hospital satisfied our criteria for the diagnosis of healed gastric ulcer before recurrence brought them again under clinic care.

The mortality statistics for the 211 resected benign cases are shown in Table . Ten of these patients died before leaving the hospital. Five, or 2.4 per cent, ay be considered to have died as the direct result of the operation. The date

Table 10. Analysis of 211 Operated Benign Ulcers· Mortality Statistics

MORTALITY	CASES Number	Per cent	CAUSE OF DEATH
tal Hospital	10	4.7	Coronary occlusion ...... 4 Cardiac failure 1
Operative	5	2.4	Bronchopneumonia (1932) 1 Peritonitis and subdiaphragmatic abscess (1933) ... 1 Pulmonary embolus (1935, 1945) .... 2 Cachexia (1936) 1

: these deaths is included with the thought that some of them at least would ot be fatalities in more recent years because of the improvements in operative chnics, preoperative and postoperative care and the availability of the antiiotics.

Tables 11 and 12 show the follow-up of the 211 benign operated cases. In ddition to the length of time during which varying proportions of this group

Table 11. Analysis of 211 Operated Benign Ulcers: Follow-up of Cases

	TOTAL NUMBER OF CASES	CLASSIFICATION OF RESULTS Poor	Fair	Good
)ied in hospital	10	—	—	—
Jo follow-up	34	—	—	—
,ess than 2 years	70*	5	7	58
: to 5 years	51†	0	9	42
years or more	46‡	0	7	39

* 1 patient died of carcinoma of the lung in four months.

† 6 patients died, 4 of cardiac disease; 1 of carcinoma of the lung, 1 of carcinoma of the pancreas.

‡ 1 patient died of vascular disease.

Table 12. Analysis of 211 Benign Operated Cases· Postoperative Symptoms and Signs

	DURATION OF FOLLOW-UP Less than 2 years Total no	Per cent	2 to 5 years Total no.	Per cent	5 years and over Total no.	Per cent
Dumping syndrome	6	8.6	3	5.9	2	4.3
Nausea and/or vomiting	10	14 3	4	7.8	3	6.5
Heartburn	5	7.1	3	5.9	2	4.3
Postprandial fullness	4	5.7	6	11.7	2	4.3
Fatigue and weakness	5	7.1	4	7.8	2	4.3
Failure to gain weight	8	11.4	5	9.8	10	21.7
Anemia*	3	4.3	10	19.3	9	19.5
Acid present	4	5.7	6	11.7	2	4.3
Total cases followed	70		51		46	

* Hypochromic or normochromic, mild in all cases.

were followed we have attempted to give an approximation of their status during the postoperative period into which they fall by classifying them as poor, fair or good. This estimation is based upon such factors as failure to gain weight, weakness, fatigability and anemia, as well as gastrointestinal symptoms. Although this cannot be more than an approximation, it does give some indication of the fact that as the time lengthens after gastric resection the patient is able to adapt himself progressively both psychologically and physiologically to his altered state. Only 1 of the entire group followed had what he considered to be a recurrence of his preoperative symptoms. Roentgenograms of the gastrointestinal tract in this patient failed to show any abnormality.

In this group 8 patients have died of known causes unrelated to the stomach so that the deaths did not have a bearing on the classification of their postoperative status.

MEDICALLY MANAGED BENIGN GASTRIC ULCERS—332 CASES

The group of gastric ulcers considered benign and treated medically (Table 13) includes 2 patients with malignant ulcer proved by postmortem examination

Table 13. Analysis of 332 Cases Diagnosed as Benign and Treated Medically: Incidence of Malignancy

			DEATHS	
LENGTH OF FOLLOW-UP	TOTAL NUMBER OF CASES	NUMBER OF MALIGNANCIES	Cause Known	Cause Unknown
No follow-up	41	—	—	—
Less than 2 years only ...	104	0	15	3†
2 to 5 years only	76	0	6	8‡
5 years or more	111 (33.4%)	2 (1.8%)	5*	4§ (3.6%)
Total	332	2	26	15

* Includes 2 patients who died with malignant ulcers.
† Ages 45, 52, 76.
‡ Ages 30, 54, 55, 55, 64, 73, 77, 84
§ Ages 54, 58, 67, 77.

six and twenty-three years after they were first seen at the Lahey Clinic. These have been cited in Table 1 in the group of proved malignancies.

Of the 330 patients remaining, 41 had no follow-up after their original diagnosis. One hundred and four were followed for less than two years. Of this group 15 have died of known causes. These include 5 patients who died in the hospital: 2 after continued hemorrhage following attempts to ligate an artery in the ulcer bed, 1 of pulmonary embolus following repair of a perforation and 2 following surgery on other areas in the gastrointestinal tract. Five died of cardiovascular renal disease. Two died of hemorrhage—1 of these patients had a duodenal ulcer and the other had had a recent protracted hospital stay during which multiple complications precluded surgical intervention. One each died of the following diseases: bladder tumor, uremia and primary carcinoma of the lung. In addition there were 3 who died of unknown causes at age 45, 52 and 76 years.

Of the patients who were followed from two to five years, 6 died from known causes; 3 of cardiovascular disease, 1 patient of streptococcus infection of the throat; 1 of uremia and 1 patient aged 65 with a duodenal ulcer of massive

hemorrhage. Eight of the 76 patients followed from two to five years died of unknown causes. They were 30, 54, 55, 55, 64, 73, 77 and 84 years of age at the time of death.

One hundred eleven patients, 33.4 per cent of the 332 patients managed medically, were followed for more than five years. Eighteen were followed for ten to fifteen years, 8 for fifteen to twenty years and 2 more than twenty years. In this

Table 14. Analysis of 332 Cases Diagnosed as Benign and Treated Medically: Incidence of Recurrence

	TOTAL GROUP				GROUP WITHOUT DUODENAL ULCER		
						Recurrence	
LENGTH OF FOLLOW-UP	Total Number of Cases	Number Diagnosed by X-ray	Number Diagnosed by Symptoms and X-ray	Recurrence, Per cent	Total Number of Cases	Number	Per cent
No follow-up	41	—	—	—	—	—	—
Less than 2 years	104	4	21	20.1	87	15	17.2
2 to 5 years	76	8	24	31.4	71	19	26.7
5 years or more	111	19	52	46.8	98	40	40.8
Total number with follow-up	291	31	97	33.3	256	74	28.9

group 7 patients in addition to the 2 with proved malignant ulcers have died. Three died of cardiovascular disease. Four died of unknown causes at age 54, 58, 67 and 77.

If in attempting to estimate the incidence of malignant disease in the group of 111 patients followed for five years or more we assume hypothetically that all of the deaths from unknown causes in addition to the 2 proved cases were due to malignancy, the incidence of malignancy is 5.4 per cent.

Table 15. Analysis of 97 Patients with Recurrence Who Did Not Have Surgical Intervention

	CASES
Did not return at time of recurrence	31
Refused operation	14
Had complicating diseases	13
Had a single recurrence with rapid recovery	10
Refused hospitalization	6
Aged	6
Severe psychoneurosis	3
Morphine addiction	1
Unexplained	13

In Table 14 the number of recurrences in each of the groups in which a follow-up was obtained is shown. This has been given as the total number of patients, those without duodenal ulcer and those in whom roentgenologic evidence of recurrence was obtained. It was considered important to note the presence of duodenal ulcers since the roentgenologic evidence for recurrence accounted for only 10.7 per cent of the cases with follow-up. Since it is impossible accurately

to place a lesion by symptoms alone, it is probable that some of the reported recurrences arose from activity in an associated duodenal ulcer when this was present. It is of interest to note that in gastric ulcer as in duodenal and jejunal ulcer the percentage of recurrences rises steadily as the time of follow-up lengthens.

Since recurrence is considered an indication for operation, in Table 15 we have attempted to analyze the findings in this group of 97 patients who were not operated upon. From the records of 13 of these patients no explanation could be found. The precipitation of recurrences is a point of great interest in all types of peptic ulcer. In the 97 patients with recurrence in the group of benign non-operative gastric ulcers, the suspected causes are given in Table 16.

Table 16. Suspected Cause of Recurrence in 97 Benign Nonresected Cases

	CASES
Dietary indiscretions	7
Illness or death in family	5
Unrelated disease	1
Morphine addiction	1
Overwork	2
Worry and tension	4
Continuation or resumption of smoking	77

COMPARISON OF BENIGN AND MALIGNANT ULCERS

The location of the ulcers is given in Figures 173 and 174. In Figure 175 the percentage of malignant ulcers occurring in each location is presented. This percentage was arrived at by dividing the number of proved malignant ulcers in each location by the total number of proved ulcers in each location.

Table 17. Comparison of Gastric Acidity in 47 Proved Malignant Ulcers and 211 Proved Benign Ulcers

	PROVED MALIGNANT CASES (47)		PROVED BENIGN CASES (211)	
ACIDITY	Total no.	Per cent	Total no.	Per cent
Anacidity	6	12.8	14	6.7
Less than 25 units	14	29.8	75	35.5
26 to 50 units	12	25.5	67	31.7
51 units and over	10	21.2	35	16.5
Not recorded	5	10.6	20	9.4

In Table 17 the free acid determinations in the proved cases of benign and malignant ulcers are shown. As might be expected, anacidity occurs almost twice as frequently in the malignant as in the benign group. It is demonstrated here, as well as generally recognized, that hyperacidity is not incompatible with gastric malignancy.

Table 18 compares the amount of weight loss in the total group of benign and malignant ulcers are shown. As might be expected, anacidity occurs almost twice occurred in a far greater percentage of the benign than in the malignant group. Table 19 shows the incidence of hemorrhage and obstruction to be similar in

the benign and malignant ulcer. Perforation occurred twice as often in the benign as in the malignant ulcer.

Table 20 gives the incidence of cholelithiasis, hour-glass deformity and x-ray deformity of the duodenum found in the study. The number of patients with

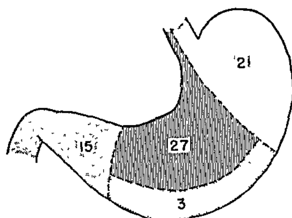


Fig. 173. 47 proved malignant ulcers.

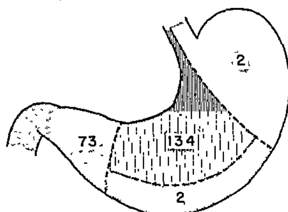


Fig. 174. 211 proved benign ulcers.

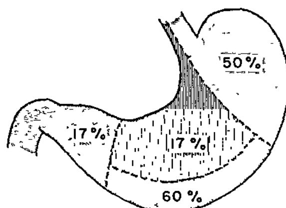


Fig 175. Incidence of malignancy in various locations.

cholelithiasis is approximately the finding in the population at large. The finding of hour-glass deformity in patients with gastric ulcer is of interest because of the preponderance in the malignant group. Two of the 6 in this group were males. X-ray deformity of the duodenum is comparable in the benign and malignant groups.

Table 21 lists the presenting symptoms of both benign and malignant cases. Night pain was more common in the malignant than in the benign cases and nausea more frequent in benign than malignant cases. Otherwise the symptoms were similar in both types of cases as would be expected. The variety of symp-

Table 18. Comparison of Weight Loss in 59 Malignant Ulcers and 541 Benign Ulcers

WEIGHT LOSS	MALIGNANT CASES (59) Total no.	MALIGNANT CASES (59) Per cent	BENIGN CASES (541) Total no.	BENIGN CASES (541) Per cent
10 pounds or less	10	16.9	70	12.9
11 to 20 pounds	13	22.0	111	20.5
21 to 30 pounds	5	8.4	55	10.1
31 pounds or over	2	3.3	52	9.6

Table 19. Comparison of Complications in 59 Malignant Ulcers and 541 Benign Ulcers

COMPLICATIONS	MALIGNANT CASES (59) Total no.	MALIGNANT CASES (59) Per cent	BENIGN CASES (541) Total no.	BENIGN CASES (541) Per cent
Hemorrhage	17	29	144	26
Obstruction	14	24	108	20
Perforation	2	3	36	7

Table 20. Associated Findings in 59 Malignant Ulcers and 541 Benign Ulcers

ASSOCIATED FINDINGS	MALIGNANT CASES (59) Total no.	MALIGNANT CASES (59) Per cent	BENIGN CASES (541) Total no.	BENIGN CASES (541) Per cent
Cholelithiasis	2	3.3	28	5.1
Hour-glass deformity	6	10.1	35	6.4
Associated x-ray deformity of duodenum	18	30.5	157	29.0

Table 21. Comparison of Presenting Symptoms in 59 Malignant Ulcers and 541 Benign Ulcers

PRESENTING SYMPTOMS	MALIGNANT CASES (59) Total no.	MALIGNANT CASES (59) Per cent	BENIGN CASES (541) Total no.	BENIGN CASES (541) Per cent
Epigastric postcibal pain	41	69.4	349	64.5
Night pain	25	42.2	136	25.5
Vomiting	12	20.3	111	20.5
Anorexia	9	15.2	77	14.2
Nausea	4	6.8	75	13.8
Abdominal pain, nonepigastric	13	22.0	101	18.6
Heartburn	5	8.4	32	5.9
Back pain	2	3.3	51	9.4
No pain	3	5.0	20	3.7

toms again emphasizes the need for careful study ir... als with any form of indigestion.

Two patients follo... nty and twenty- ... *respectively, have special interest.*

The first, a male ag... first seen in ... ort hi... symptoms somewhat s... ma of the ... was

lesser curvature saddle lesion, with no demonstrated evidence of duodenal ulcer. He made rapid recovery both clinically and by roentgen examination, never had a recurrence, and died in February 1948, at the age of 83 years, of "natural causes."

The second case, a woman aged 52, when first seen in November 1924, had a very large saddle ulcer of the lesser curvature and a duodenal defect. There was a history of ulcer distress for thirty-five years and recent massive hemorrhage. There was a high range of gastric acidity. The large gastric ulcer healed completely. She had no recurrence from 1924 to 1946 or 1947 (twenty-two or twenty-three years). Cholecystectomy was carried out for gallstones in November 1937 at which time a careful search by the surgeon revealed no evidence of a scar of the gastric ulcer. In 1944, patient (aged 72 years) had cerebral arteriosclerosis and probable cerebral hemorrhage, with marked deterioration of the mental status. She was in the custodial care of the family who observed that beginning in August 1946 the patient refused all foods which were not white limiting her diet to milk, vanilla ice cream and creamed foods. By January 1947 she was taking 2 to 3 quarts of milk and cream daily. In August 1947 the patient was obviously having epigastric pain which was relieved by warm milk, and in September 1947, three weeks before death, she vomited coffee ground material. This patient died on October 18, 1947 after recurrent cerebral hemorrhage.

Postmortem findings in the stomach were as follows: specimen consisted of a stomach and 8 cm. segment of attached duodenum. The serosa was smooth. The lesser curvature fat was firmly adherent about 4 cm. proximal to the pylorus. On the lesser curvature 4 cm. proximal to the pylorus was a depression, 4 by 3 cm., having raised, firm but resilient borders. The base of the depression was white. Cross-sectioning revealed thickening in this region up to 1.5 cm. The fundus of the stomach had lost the usual rugose pattern and had innumerable petechial hemorrhages. The wall was very thin. No enlarged nodes were found in the lesser or greater curvature fat. The microscopic diagnosis was: carcinoma simplex with mucinous foci.

This patient probably had recurrence of symptoms at some time between August 1946, when she would take only white foods, and August 1947, when she was obviously having epigastric pain, relieved by warm milk. At postmortem examination, in October 1947, the lesion in the stomach was found to be carcinoma simplex with mucinous foci, without enlarged nodes in the lesser or greater curvature fat. The liver was described as normal. The pathologist searched carefully for any other scar which might represent the original ulcer of 1924, but none was present. The only deduction to be drawn, therefore, is that after twenty-two or twenty-three years, this patient had a recurrence of her gastric ulcer which was immediately malignant, or became so during the fourteen months before her death.

DISCUSSION OF FINDINGS

The authors of this paper believe that the above study furnishes by no means final nor decisive data on the controversial point for which it was undertaken: namely, whether all gastric ulcers should be regarded as surgical and resection done. This study, we believe, should be only one of many throughout the country. It is important that there be a correlation of surgical and gastroenterologic opinion and definite policies established, so that the individual gastroenterologist and surgeon, whose experience is still insufficient for reasoned judgment may have some evidence to guide him to the correct therapy for the individual patient.

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10 pounds or less	10	16.9	70	12.9
11 to 20 pounds	13	22.0	111	20.5
21 to 30 pounds	5	8.4	55	10.1
31 pounds or over	2	3.3	52	9.6

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PRESENTING SYMPTOMS	MALIGNANT CASES (59) Total no.	Per cent	BENIGN CASES (541) Total no.	Per cent
Epigastric postcibal pain	41	69.4	349	64.5
Night pain	25	42.2	136	25.5
Vomiting	12	20.3	111	20.5
Anorexia	9	15.2	77	14.2
Nausea	4	6.8	75	13.8
Abdominal pain, nonepigastric	13	22.0	101	18.6
Heartburn	5	8.4	32	5.9
Back pain	2	3.3	51	9.4
No pain	3	5.0	20	3.7

toms again emphasizes the need for careful study in individuals with any form of indigestion.

Two patients followed for twenty and twenty-three years, respectively, have special interest.

The first, a male aged 63 years, when first seen in 1928, had a short history of ulcer symptoms somewhat suggestive of carcinoma of the stomach. His ulcer was a very large

interesting to note that contrary to an often expressed opinion of many of us, no dependence can be placed upon the associated x-ray finding of duodenal ulcer with the gastric lesion in the differentiation of benign and malignant ulcer; in our cases, an x-ray defect of the duodenum was diagnosed in 31 per cent of those gastric ulcers which were proved malignant. This finding is now being further investigated and will be published in a separate study.

3. In 111 cases followed from five to twenty-three years, only 2 had recurrences with malignancy (1.8 per cent of this group). Adding the 4 deaths of unknown cause to these 2 and assuming (entirely hypothetically) that these deaths were from cancer of the stomach, the percentage would still be only 5.4 of the 111 cases. Even this percentage, in part at least hypothetical, compares favorably with the hospital mortality of 4.7 per cent and operative mortality of 2.4 per cent in the 211 cases of benign ulcer resected and is appreciably lower than the usually estimated incidence, 10 per cent, of malignancy in gastric ulcer. To be sure, the latter was accumulated chiefly in earlier years when surgical and anesthesia technics were not yet at their present optimum.

4. The length of follow-up preceding resection in malignant gastric ulcers is the vulnerable point in our gastroenterologic experience. The mistakes made in the cases of the 20 patients (Table 4) who were carried along on medical treatment from two months to seven years, and then operated upon and found to be malignant, are not to be condoned unless, as we believe was true in certain of these cases, malignant changes occurred only with the later recurrence. In 1941, one of us (S.M.J.) called attention to evidence which seemed to indicate that such changes might occur in recurrent gastric ulcer, and since that time, this belief has been strengthened by further evidence, of which the case history quoted is a notable and striking example. Dr. Shields Warren, Pathologist at the New England Deaconess Hospital, concurs in this opinion. He believes that with the healing and recurrent breaking down process, cell changes occur which may give rise to malignancy. There is, in this respect, perhaps an analogy between gastric ulcer and chronic endocervicitis and possibly also with ulcerative colitis. These 20 cases then were obviously the individuals in this entire group of whom it is known that they might have been saved a death from cancer of the stomach from which they died, if they had been operated upon as soon as first seen. They constitute 3.3 per cent of the total group.

5. This potentiality of the recurrent gastric ulcer to become malignant, if accepted as factual, must then be discussed in the light of this study. Our only logical conclusion regarding recurrence is that since in our opinion the recurrent gastric ulcer harbors potential malignancy, any recurrence must be an indication for resection. Our study shows that 40.8 per cent of 98 cases of gastric ulcer unassociated with duodenal ulcer, followed for five years or more had recurrences while 59 2 per cent did not. This indicates that about 60 per cent of those cases of gastric ulcer (without duodenal ulcer) certainly had no malignant changes in their original ulcer, and if they could be protected against recurrence they would be safe from the danger of future malignancy in the area of the original gastric ulcer and need not have their normal gastric function disturbed by resection.

The policy of resection of all recurrent ulcers will result in the resection of

Several points of special interest have been suggested by our study: 1, The male patient is a little more than twice as prone to gastric ulcer as the female, but more than four times as prone to malignant ulcer.

In the differential diagnosis, x-ray, the history and the clinical course of the patient are our chief guides. Of this, x-ray is the most valuable and the importance of careful fluoroscopic and film examination cannot be overestimated.

2. The symptoms are disarmingly similar in the benign and malignant cases In a small percentage they are absent in both. In the individual case the character of the symptoms may vary so far from the classical standard as to be misleading. In our study, for example, loss of weight occurred in a larger percentage of the malignant cases only in those who had lost twenty pounds or less, while in those who had marked weight loss (thirty-one pounds or more) those with benign gastric lesions predominated almost 3 to 1.

Table 22. Patients Who Had Gastroscopy Performed (124 Cases)

		CASES		PER CENT
Examination unsatisfactory		31		25.0
Cardiospasm, hour-glass stomach, lesion in "blind spot" of instrument, lesions not visualized although present by x-ray and/or at surgery				
Lesion visualized		93		75 0
Diagnosed benign, confirmed by x-ray and/or surgery	60		64.5	
Diagnosed benign and proved malignant	4		4.3	
Diagnosed question malignant, proved benign	21		22.5	
Diagnosed malignant and proved malignant	8		8 6	
73.1 per cent accurate.				
26 8 per cent inaccurate.				

The location of the lesion has some significance since as is shown in Figure 175 the greater curvature and fundus have the highest percentages of malignancy, 60 per cent and 50 per cent (although their total incidence is too small to be conclusive). The prepylorus and pylorus, and the corpus show an incidence of malignancy of only 17 per cent in each location in this series. It should be especially noted that less than one-fifth of the prepyloric lesions in our series were malignant. Furthermore, the same percentage of malignancy is found on the lesser curvature of the corpus. Nevertheless the greater frequency of ulcers in these regions diminishes the percentile incidence but does not change the fact that the greatest number of malignancies are to be found in these areas.

Gastroscopy (Table 22) must be regarded only as an accessory to x-ray in the differentiation of benign and malignant gastric ulcer, chiefly because of the occurrence of these lesions in areas which are blind spots to the gastroscopist. In 4.3 per cent of this series of 93 cases in which the lesion was visualized a gastroscopic diagnosis alone of "benign ulcer" would have suggested a false security, and in 25 per cent of all cases gastroscoped no help at all was obtained Table 17 shows that the dependence upon acid values is, as has long been suspected, of little significance in differential diagnosis, although the percentage of cases showing achlorhydria is greater in malignant than in benign cases. It is

SUMMARY

The evidence collected in this study presents in summary, grounds for the following opinions:

1. That gastric ulcer, while a definitely potential origin for malignancy, is not so perilous that the patient who has it cannot be treated as an individual case, rather than by a general policy of resection of all cases.

2. That the first occurrence of gastric ulcer must be treated with intensity and persistence—so that proved complete healing is obtained, and absence of recurrence maintained.

3. That failure of complete healing, within six to eight weeks as a maximum, and all recurrences be treated as soon as possible by resection.

many benign ulcers, as indicated in Table 8 where 42 per cent of the 211 cases had resection because of a diagnosis of positive or suspected malignancy, and 33 per cent because of recurrence. However, this sacrifice must be condoned as a concession to the ultimate good and safety of the patient. Table 16, which shows the suspected causes of recurrence in benign cases is of interest because in 80 per cent of these cases, persistence or resumption of smoking was the only known impeachable factor.

6. The question of dependence upon evidences of healing must again be discussed in the light of this study. The established criteria for healing are still valid: complete disappearance of the x-ray defect, complete subsidence of symptoms and disappearance and nonrecurrence of occult blood in the stools. Of these three criteria, the x-ray evidence is of greatest value. By complete disappearance of the x-ray defect is meant not only the disappearance of the crater, but a complete return of flexibility in the gastric wall at the site of the ulcer and the absence of the so-called dimpling defect. Any rigidity in this area may well indicate malignant change at the base of what appears to be a healed ulcer. Complete absence

Table 23. Healing Time in Patients with Gastric Ulcer with Frequent X-rays (145 Cases)

HEALING TIME	NUMBER OF CASES
1 week	4
2 weeks	19
3 weeks	32
4 weeks	29
5 weeks	17
6 weeks	13
7 weeks	7
8 weeks	15
Over 8 weeks	9

of rigidity is of as much importance as the disappearance of the crater. In our study, it was found that the speed of healing was apparently not at all related to (1) the danger of recurrence; (2) the duration of symptoms and (3) the age of the patient at the time treatment was started. As stated above there were 20 cases in our series in which operation for suspected malignancy was not done within two months, but which when finally operated upon, had proved malignancy.

Our study (Table 23) shows that healing in 145 cases studied with frequent x-rays, was complete in 84 cases within four weeks—and in 52 cases between five and eight weeks. The progress of healing should be obvious in three to four weeks, and in all cases complete within six to eight weeks. Furthermore, all other subjective and objective signs should be favorable if the case is to be continued on a medical regimen. The patient should be adequately instructed as to the nature of gastric ulcer and the potential danger of recurrence. This educational program has two purposes: (1) the complete cooperation of the patient in maintenance of healing, and (2) his immediate return for examination in case of recurrent symptoms. Upon these two factors safety in treating gastric ulcer depends. Unless there can be assurance that these measures will be carried out, resection may well be safer.

SUMMARY

The evidence collected in this study presents in summary, grounds for the following opinions:

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PARTIAL GASTRIC RESECTION FOR PEPTIC ULCER

SAMUEL F. MARSHALL

Partial gastrectomy is still a most important surgical method for treatment of peptic ulcer, whether duodenal, gastric or jejunal, and at the Lahey Clinic we continue to place most of our reliance for permanent effective treatment of ulcer on resection of the stomach. With the advent of vagotomy we had hoped that many of the difficulties of resection, both technically and postoperatively, could be avoided. As Wilkinson has pointed out, with vagotomy the stomach could be left intact, a large percentage (88) of ulcer patients could be relieved of pain, and anacidity or low acid values could be obtained in a fairly large group of cases, but this decrease in gastric acid could not always be attained nor was the resultant anacidity permanent in many cases. At the Lahey Clinic vagotomy has been carried out in over 90 cases. In a recent review of 62 patients with vagotomy, it was evident that these patients had more postoperative difficulty, more severe and more persistent symptoms and just as many recurrent ulcers as a similar group of patients who had partial gastric resection only. The problem of vagotomy is by no means settled but the complications and dangers should be recognized as well as the benefits to be obtained from this lesser technical procedure as opposed to the more radical operation of partial resection.

FACTORS ESSENTIAL FOR GOOD RESULTS

Partial gastrectomy can be done with a large margin of safety and with excellent results in the majority of cases but any good postoperative results depend upon a number of factors.

First, the results depend upon the proper selection of patients to be submitted to surgical treatment. The indications for surgical treatment have been restated many times and are clear: perforation, repeated massive hemorrhages, obstruction and failure to relieve symptoms by adequate medical treatment, demand surgical interference. Gastric ulcers which fail to heal under medical treatment, or recur after healing, likewise demand resection. It is our feeling that vagotomy should almost never be used for gastric ulcer, since surgical interference is advised because of the uncertainty of the ulcer being benign or malignant. In a previous study of the problem of gastric ulcer, we found 26 malignant ulcers among 131 gastric ulcers, an incidence of 19.6 per cent; these patients were submitted to surgery because of failure of the ulcer to heal or because of recurrence of gastric ulcer after healing under medical treatment.

Second, good results after resection depend upon adequate resection; two-thirds or three-fourths of the stomach must be removed to prevent recurrent ulcer. Removal of the pylorus or antral area of the stomach carries as much surgical risk as a high resection and will result in recurrent ulcer in a large percentage of cases.

Originally published in Surgical Clinics of North America, 29.767–777 (June) 1949.

Third, operation, whether partial resection or gastroenterostomy, does not permit the patient to eat everything and to avoid long-continued postoperative ulcer management. He should follow a careful dietary regimen and be under the care of his gastroenterologist for a long period of time to avoid recurrent ulcer.

Lastly, meticulous attention to technical details of the operation, avoidance of contamination from visceral contents during operation, control of hemorrhages and avoidance of trauma will make for lower mortality and will contribute greatly to an uneventful, uncomplicated postoperative recovery.

The type of technical procedure employed in partial resection of the stomach makes no great difference if sufficient stomach is removed and if the ulcer is also removed, which can be done in almost every case if the relationship of the ulcer, especially duodenal ulcer, to important structures such as the common bile duct is recognized. Resections which do not include removal of the ulcer are palliative resections and are not true radical partial resections and should not be termed so. This type of palliative resection may result in a high percentage of recurrent ulcers. The Finsterer resection with exclusion of the ulcer is such an operation and has not been used in this clinic for seven or eight years. In an early series of cases in which the Finsterer procedure was occasionally employed, ulceration recurred in over 50 per cent. In several instances in which a jejunal ulcer recurred after a high resection but with the duodenal ulcer not removed, we were able to effect healing of the recurrent ulcer by simply excising the unremoved antral part of the stomach.

MODIFIED HOFMEISTER TECHNIC

The method of resection of the stomach routinely employed in the clinic for the past ten years has been a modification of the Hofmeister technic of partial gastric resection. The gastrojejunal anastomosis is made anterior to the transverse colon with the proximal loop of jejunum placed at the greater curvature of the stomach. As stated previously, a radical resection of the stomach is uniformly employed with removal of two-thirds or three-fourths of the stomach. It is our opinion that recurrence of ulcer with few exceptions is related to a large degree to insufficient removal of the stomach.

A left paramedian or transrectus incision is made, extending from the left costal margin to the level of or below the umbilicus, the incision is made long enough to permit adequate exposure of the stomach and duodenum. The incision on the left side of the abdomen is preferred since the pylorus normally lies in the midline of the abdominal cavity and the duodenum is only slightly to the right. This incision allows ready approach to the fundus and even the cardia of the stomach and thus permits a high resection to be carried out easily under the left costal margin. The muscles, fascia and other layers of the incision in the abdominal wall are protected by abdominal pads containing a layer of waterproof cellophane between the gauze to prevent contamination of the incision when the lumen of the stomach or jejunum is opened into during the operation.

After exploration of the abdominal viscera, the location of the ulcer is identified and its relation to other structures is determined. Should the ulcer be located in the duodenum, its relationship to the common bile duct and ampulla of Vater must be established before attempting to mobilize the duodenum and

pylorus in preparation for resection. In chronic, deeply penetrating duodenal ulcers, in which there is much inflammatory reaction about the ulcer, a layer of scar tissue envelops the first and second portions of the duodenum which will conceal the outline of the duodenum. The convexity of the duodenum is mobilized by division of this scar tissue and peritoneum parallel to the upper border of the duodenum, the course of the duodenum and its relation to the gastrohepatic ligament are easily delineated and the duodenum may be turned medially. If the ulcer is low in the duodenum or adherent to the gastrohepatic ligament, the common bile duct must be exposed and visualized (Fig. 176). The common bile duct is then incised longitudinally, and the ampulla of Vater is dilated by the Bakes dilators in order that a limb of a rubber T-tube can then be passed into the

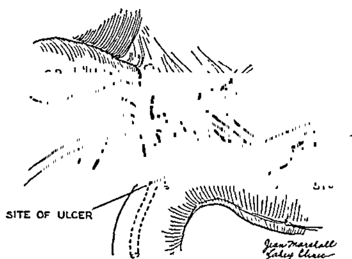


Fig. 176. Pyloric end of stomach and first part of duodenum. The ulcer is adherent to the gastrohepatic ligament and common bile duct. The common bile duct has been exposed, incised longitudinally and a rubber T-tube inserted with the long limb passed through the ampulla of Vater into the duodenum. This will aid materially in establishing the location of the ampulla of Vater and permit easier dissection of the duodenum and ulcer from the common bile duct and pancreas.

duodenum. This placing of the T-tube into the bile duct and through the ampulla of Vater into the duodenum establishes definitely the course of the bile duct and its relation to the ulcer. The ulcer may then be removed without danger of injury to the common bile duct. This is a simple but extremely important maneuver in preventing injuries to the bile duct with their resultant stricture formation and postoperative obstruction to the flow of bile into the duodenum. Intubation of the common bile duct does not increase postoperative morbidity or adversely affect mortality but, on the contrary, greatly facilitates mobilization of the duodenum and removal of the ulcer in difficult cases. However, it is well to emphasize that exposure and intubation of the common bile duct are necessary in only a few cases, that is, those in which the ulcer is low in the duodenum or induration and inflammation about the ulcer involves the structures about the common duct.

When it is definitely established that a duodenal ulcer can be removed without injury to these important adjacent structures, the greater and lesser curvatures of the stomach are mobilized by clamping, section and ligation of the blood supply

in the gastrocolic and gastrohepatic omentum (Fig. 177). If the patient is obese or the omentum is thickened with fat, it is detached from the colon and resected with the stomach. This makes the resection much easier and permits an easier exposure and direct ligation of large vessels around the pylorus; it also permits an anterior gastrojejunostomy to be made more easily. Mobilization of the pyloric area and duodenum can be facilitated by passing a sponge posterior to the stomach and using this as a traction tape to elevate the stomach. Following mobiliza-

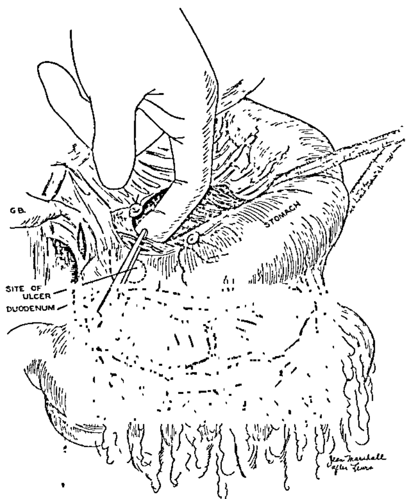


Fig. 177. Mobilization of the stomach and duodenum. The gastrocolic and gastrohepatic omenta have been divided and ligated. The right gastric vessels are shown along the superior border of the duodenum Note the relation of the common bile duct to the duodenum and ulcer. The gauze sponge is passed around the stomach and used to elevate the stomach.

tion of the pylorus and duodenum, the duodenum is divided and the distal divided end closed by one of several methods (Fig. 178). The mobilization of the lower end of the stomach and the duodenum is made readily if one recalls that the gastrocolic omentum and mesocolon are fused just below the antrum of the stomach. This area of fusion consists of avascular areolar tissue which separates easily if the peritoneum over the pancreas is divided at the point of reflection onto the posterior wall of the stomach (Fig. 179), permitting the mesocolon with its middle colic vessels to be brushed down gently with gauze. This will expose the gastroduodenal artery as it courses over the head of the pancreas posterior to the antrum of the stomach. This artery can be divided and ligated at the inferior

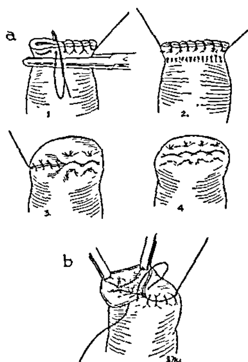


Fig. 178. Closure of the duodenum; several methods may be used as shown in *a* and *b*.
a, The duodenum stump may be sutured with a running stitch of chromic 0 catgut (1) and the clamp removed (2). The closed duodenal end is then inverted with interrupted mattress sutures of black silk (3, 4).

b, When the duodenal stump after mobilization and removal of the ulcer is short, no clamp is applied in order that duodenal length may be conserved; a Connell stitch of chromic 0 catgut is used to invert the open end of the duodenum; this is then reinforced with interrupted mattress sutures of black silk. This in turn may be further reinforced by suturing the closed end of the duodenum against the scarred head of the pancreas.

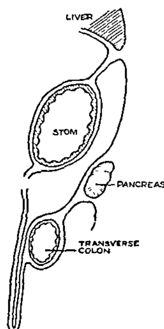


Fig. 179. The layers of the peritoneum are shown in relation to the omentum, stomach and lesser peritoneal cavity. Recognition of the anatomy of these peritoneal layers permits easier mobilization of the pyloric part of the stomach and duodenum.

border of the pancreas. The chronic indurated ulcer which is usually on the posterior wall of the duodenum may be adherent to the pancreas and usually such an ulcer has penetrated the wall of the duodenum so that the ulcer base consists of pancreatic and scar tissue. It is not necessary to remove this base; the ulcer is removed by detaching the ulcer orifice on the duodenal wall from its ulcer base.

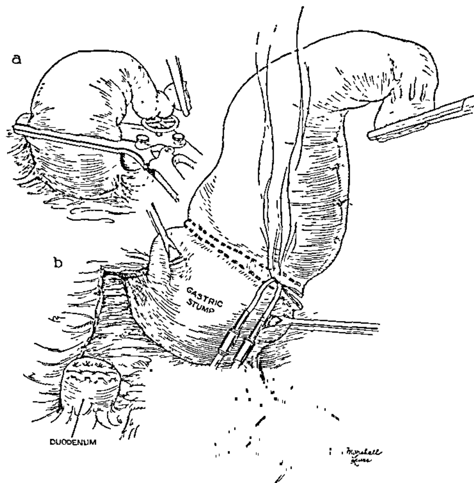


Fig 180. The duodenum has been divided and closed by inversion. The stomach is elevated and drawn to the left.

a, The von Petz clamp has been applied at the level at which the stomach is to be divided, leaving about one-third or one-fourth of the stomach above the clamp.

b, The stomach is now divided between the double row of inserted clips with the cautery. Note that the borders of the stomach above the clips have been cleaned of omental tissue to permit more accurate inversion of corners and more accurate anastomosis of jejunum to stomach.

With the duodenum divided and the distal end closed, the stomach is drawn upward and to the left of the abdomen (Fig. 180). If the resection is done for *gastric* ulcer, the ulcer is often found attached to the pancreas or liver. This adherent indurated ulcer can be detached easily under direct vision by sharp or blunt dissection. The left gastric artery is visualized and divided at a high level along the lesser curvature of the stomach. The lesser curvature of the stomach is cleaned of omental tissue and this is likewise done on the greater curvature, ligating one or two of the short gastric vessels. This clearing of the borders of the stomach will permit accurate approximation and inversion of the gastric wall

at the borders of the stomach (Fig. 180); about two-thirds or three-fourths of the stomach is removed. Before dividing and removing this portion of the stomach, however, the loop of jejunum which is to form the gastrojejunal anastomosis close to the ligament of Treitz is brought anterior to the colon. This will prevent unnecessary contamination at the time of division of the stomach, so that the

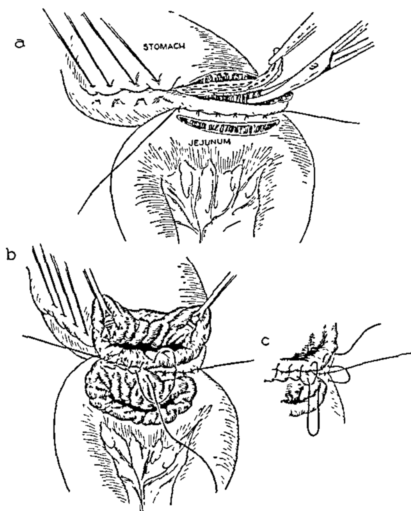


FIG. 181. The lesser curvature end of the transected stomach is inverted with clips in place with a continuous chromic 0 catgut suture which is then reinforced with interrupted mattress sutures of black silk (see *a*). The jejunum is sutured to the posterior wall of the stomach at the site of anastomosis with interrupted sutures of black silk. The jejunal lumen is opened into by longitudinal incision and the stomach is opened by cutting away the clips in the uninverted end of the stomach. This will form the gastrojejunal stoma. A second posterior continuous interlocking stitch of chromic catgut is then placed and this is continued anteriorly as a Connell stitch (*b* and *c*) to close the anastomosis and form the stomal orifice.

protecting abdominal pads do not have to be disarranged to select the proper loop of jejunum.

The von Petz clamp is now applied at right angles to the long axis of the stomach at the level at which the stomach is to be divided and the clips are inserted (Fig. 180). A Payr clamp is applied just distal to the double row of clips and the von Petz clamp is removed. A Babcock clamp is applied at the level of the clips on the lesser and greater curvature to support and elevate the gastric stump when the stomach is divided by cautery between the two rows of clips.

The upper one-half or two-thirds of the transected end of the stomach with the clips in place is inverted with a continuous suture of No. 0 chromic catgut on an atraumatic needle (Fig. 181). This suture line is reinforced with a second layer of interrupted mattress sutures of silk. The lower uninverted end of the stomach along the greater curvature will form the gastric stoma into the jejunum.

The selected loop of jejunum is brought anterior to the transverse colon and is sutured to this uninverted end of the stomach with interrupted mattress sutures of silk. The gastrojejunal stomal orifice should be about three fingerbreadths in width.

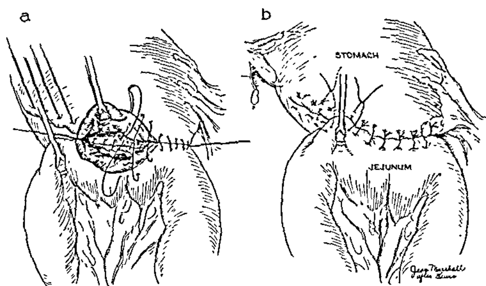


Fig 182 Completion of the gastrojejunal anastomosis which completes the partial resection of the stomach.

a, Note that the chromic catgut stitch which forms the second posterior suture layer is continued anteriorly as a Connell suture which closes the lumen of the stomach and of the jejunum to form the gastrojejunal stoma.

b, The completed anastomosis which is reinforced with interrupted sutures of black silk. Note that the jejunum beyond the anastomosis is sutured to the closed and inverted end of the stomach. Note also that, for reinforcement, the gastrocolic omentum is sutured in the angle formed by the stomach and jejunum at the greater curvature of the stomach.

The jejunum is opened by a longitudinal incision and the uninverted end of the stomach is opened by excising the crushed portion with its clips (Fig. 181). Contamination is prevented by suction of jejunal and gastric contents. All active bleeding points are ligated by fine catgut. A second posterior suture of chromic catgut is begun at the right end of [illegible] stitch through all layers of the j[illegible] curvature of the stomach. This posterior interlocking suture of catgut is then continued anteriorly from the greater curvature end to the right as a Connell stitch, serving to invert the gastric and jejunal edges and thus closing the anastomosis and forming the gastrojejunal stoma. This anterior suture line is reinforced with interrupted (Lempert) sutures of silk.

The distal jejunal loop beyond the stomal area toward the lesser curvature is buttressed against the closed inverted end of the transected stomach to reinforce the suture line and to remove tension on angle sutures of the anastomosis (Fig. 182). The gastrojejunal angle at the greater curvature is reinforced by suturing

the divided end of the gastrocolic omentum to this angle. The proximal jejunal loop is thus placed at the greater curvature.

Entero-enterostomy between the proximal and distal jejunal loops should not be done. This not only is unnecessary for proper drainage of stomach but deflects the alkaline duodenal contents from the stomal orifice. This is an important factor in preventing recurrent ulcer at the gastrojejunal anastomosis. The abdominal cavity is inspected for bleeding points before closing the abdominal wound, which is done without drainage.

The abdominal wound is closed in layers of the peritoneum, fascia, muscle and skin; the peritoneum is closed with a continuous suture of chromic catgut. By use of the waterproof cellophane pads, any contamination of the abdominal wall incision is prevented. We are, therefore, able to employ interrupted silk sutures in approximating muscle, fascia, subcutaneous tissue and skin. This is also a layer closure. Should the patient be elderly or have poor abdominal wall tissues, further reinforcement of the incision may be obtained with a few interrupted retention sutures of heavy silk. These latter stitches are rarely necessary and the large percentage of these wounds heal without infection, and rarely is disruption of wound observed. The operative mortality following partial gastric resection for peptic ulcer for the past 12 years has been 2.4 per cent in 1079 cases (Table 1).

Table 1. Partial Gastric Resection for Peptic Ulcer, 1937–1948 Inclusive

	NUMBER OF PATIENTS	NUMBER OF POSTOPERATIVE DEATHS	OPERATIVE MORTALITY, PER CENT
Duodenal ulcer	710	18	2.53
Gastric ulcer	205	3	1.46
Jejunal ulcer	133	3	2.3
Gastrojejunocolic fistula	31	2	6 5
Total operated cases	1079	26	2.4

Partial gastrectomy can be done with low mortality even with many patients who have serious complicated ulcers. Postoperative results following partial gastrectomy are, in general, excellent.

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DIAGNOSIS AND TREATMENT OF GASTROJEJUNOCOLIC FISTULA

FRANK H. LAHEY, CORNELIUS E. SEDGWICK AND SAMUEL F. MARSHALL

INTRODUCTION

One of the most serious sequelae in the treatment of peptic ulcer by gastrojejunostomy is the formation of a gastrojejunocolic fistula. It is estimated as occurring in 10 to 30 per cent of all patients with marginal ulcers who require operation[7] (Ransom 17 per cent, Benedict 23.8 per cent, Verbrugge 11.31 per cent, Walters and Clagett 13.6 per cent). If the incidence of marginal ulcer is about 5 per cent we would expect gastrojejunocolic fistula to develop in roughly 1 in every 100 gastrojejunostomies performed for peptic ulcer. This is probably too high an estimate. An indication that this undesirable complication is not common is the fact that no one person or clinic has reported any large group of cases in spite of the fact that during the past two or three decades many gastrojejunostomies have been performed for the treatment of peptic ulcer. Interestingly, the incidence of duodenal ulcer is definitely less in women than in men, the formation of a gastrojejunocolic fistula in a woman is indeed a rare occurrence, and few cases have appeared in the literature.

The primary factors responsible for the formation of a gastrojejunocolic fistula are the same as those thought to be the etiologic factors of peptic ulcer. This complication may be expected more often in the patient who is the typical ulcer type, in those who originally had duodenal rather than gastric ulcer, and in those who originally had high gastric acidity and who were most refractory to medical treatment. As with marginal ulcers, gastrojejunocolic fistula always follows gastrojejunostomy. It is much less frequent following gastrojejunostomy combined with gastric resection than when gastrojejunostomy is instituted as the sole procedure. There are also secondary causative factors relative to the technical aspects of surgically constructing a gastrojejunostomy which may predispose to the formation of a gastrojejunocolic fistula. It is assumed that all gastrojejunocolic fistulas follow the formation of a marginal or jejunal ulcer. If the transverse colon is closely adherent to the area of ulceration at the stoma of the stomach and jejunum, one may expect adjacent inflammation to spread more rapidly to the wall of the colon, with subsequent fistulous formation, than if the mesenteric border of the colon is at a distance from the gastrojejunostomy. For this reason it is thought that an anterior gastroenterostomy will be followed by fewer gastrojejunocolic fistulas than posterior gastroenterostomy. Therefore,

Revision of article entitled "Diagnosis and Treatment of Gastrojejunocolic Fistula" by Drs. Frank H. Lahey and [illegible] Practice." combined [illegible] published in Annals of [illegible], J. B. Lippincott Co., publishers.

if posterior gastroenterostomy is preferred, it is important to bring the jejunum through the transverse mesentery as far away from the border of the colon as possible.

Jejunal ulceration may occur at the stoma of a gastrojejunostomy or it may occur several centimeters from the margin of the stoma. Likewise, a gastrojejunocolic fistula may develop close to, or at a distance from, the stoma. The fistula may be between the stomach and colon, jejunum and colon, or stomach, jejunum and colon. It may be very small and allow little fecal material to pass into the stomach and jejunum, or it may be quite large and divert large quantities of colon contents into the upper gastrointestinal tract. A gastrojejunocolic fistula at operation appears grossly as an edematous, indurated mass in the region of the transverse colon. Cleavage planes are difficult to establish because of the adhesions binding the loops of bowel together. Frequently, the surrounding inflammation has produced partial intermittent obstruction and both the large and small bowel may be thick-walled and dilated. Because of the irritating effects of the fecal material on the gastric mucosa, gastric hypertrophy is frequently evident.

SYMPTOMATIC AND PHYSICAL DIAGNOSIS

The symptoms, both subjective and objective, of gastrojejunocolic fistula closely follow the physiopathology of the abnormality. Since the fistula develops secondary to a marginal or jejunal ulcer, the patient's record contains a history of a *previous gastrojejunostomy* or *gastrectomy*. At an interval varying from a few months to several years after the operation, *abdominal pain* and *discomfort characteristic of a marginal ulceration* develop. The abdominal symptoms may subside with the formation of the fistulous tract but more annoying and disagreeable symptoms develop. The gastrojejunocolic fistula not only allows stomach contents to flow directly into the colon but, more important, allows colonic material to regurgitate into the stomach and jejunum, thus *producing fecal belching and at times fecal vomiting without evidence of intestinal obstruction*. Furthermore, the regurgitated fecal contents cause irritation to the gastric and jejunal mucosa, producing *persistent diarrhea* so characteristic of this disease. If the fistulous tract is large the diarrhea is severe. If the fistulous tract is small and intermittently plugged with food or mucosal folds, the diarrhea may be slight and intermittent.

The patient with a gastrojejunocolic fistula is not only chronically ill, with a poor appetite and low nutritional intake, but the nutrition he does take either passes directly into the colon, by-passing the large absorptive area of the small bowel, or if nutrition does enter the small bowel the diarrhea allows little absorption and subsequently large amounts of water, electrolytes, nutrition and vitamins are lost. The result is *severe, rapid malnutrition, anemia, wasting, avitaminosis, dehydration and electrolyte imbalance.*

ROENTGENOLOGIC DIAGNOSIS

The diagnosis of gastrojejunocolic fistula is usually confirmed roentgenologically after the ingestion of a barium meal or the administration of a barium enema (Figs 183 and 184). Frequently it is difficult to demonstrate the fistula by the barium meal, but the failure to do so does not necessarily exclude the

presence of this abnormality. Failure to demonstrate the fistula after ingestion of barium in all probability is due to food particles or folds of mucosa temporarily occluding the orifice of the fistula. A barium meal, however, is usually the first roentgenologic study in patients suspected of gastrojejunocolic fistula and, although a fistulous tract may or may not be discovered, this study gives one an opportunity to visualize the upper gastrointestinal tract and in many instances the niche of the marginal ulcer may be demonstrated or other upper gastrointestinal abnormalities brought to light.

The second study is the administration of the *barium enema*. As colonic regurgitation into the stomach is a frequent manifestation of gastrojejunocolic



Fig. 183.

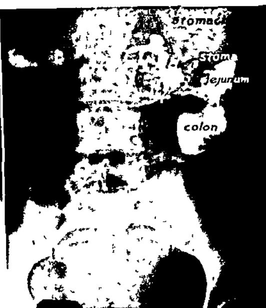


Fig. 184.

Fig 183. Roentgenogram taken after a barium enema showing a gastrojejunocolic fistula. T.C. indicates the transverse colon; D.C. the descending colon and "X" the fistula.

Fig. 184. Roentgenogram taken after ingestion of a barium meal, showing a gastrojejunocolic fistula.

fistula, the fistulous tract is usually demonstrated without difficulty. Care must be taken relative to the amount of barium given. If the barium passes in too great a quantity from the colon into the jejunum and stomach, loops of small bowel may fill too rapidly and obscure the fistulous tract. As soon as the barium enters the stomach the administration of the enema must immediately be stopped.

GASTROSCOPIC DIAGNOSIS

Gastroscopic examination of the stomach is rarely, if ever, used in cases of suspected gastrojejunocolic fistula. Furthermore, to examine the stomach with the gastroscope the stomach must be inflated with air. This may be impossible with a large gastrojejunocolic fistula since the air would rapidly leak into the jejunum and colon. Also, most marginal ulcerations occur in the jejunum rather than in the stomach and, although a marginal ulcer on the gastric side of the gastroenterostomy might be easily visualized, even if the gastroscope is passed through the stoma, it would be difficult to visualize the ulcer in the jejunum in

the presence of colonic regurgitation. The little information gained by gastroscopy in diagnosing gastrojejunocolic fistula does not warrant its use.

LABORATORY FINDINGS

The laboratory findings in the patient with a gastrojejunocolic fistula are those changes which would be expected in a patient with extreme malnutrition, anemia, avitaminosis, dehydration and electrolyte imbalance. Furthermore, as the ingested nutrition passes rapidly through the small intestine or is diverted directly from the stomach into the colon, the feces should show changes characteristic of incomplete digestion and absorption.

Blood. *Blood Cell Changes.* Bleeding from ulceration of the stoma and malnutrition are evidenced by low hemoglobin and hematocrit values. Dehydration may, however, mask this anemia and an elevated hemoglobin and hematocrit reading may be misleading. With great weight loss, blood volume is decreased, and blood volume studies will give valuable information. Infection is reflected by an elevated leukocyte count and increased sedimentation rate.

Blood Electrolyte and Fluid Changes. The persistent diarrhea allows large losses of sodium, potassium, chlorides and bicarbonate. Acidosis may develop, with low serum chloride and low carbon dioxide combining power. In cases of severe diarrhea, however, it must be kept in mind that the main electrolyte loss is the cation *sodium* in excess of anions, chloride or bicarbonate, and that all the sodium replaced to combat this acidosis should not be in the form of sodium chloride, or hyperchloremia may develop. Furthermore, with diarrhea, large quantities of potassium are lost and low serum potassium may develop. Low serum potassium may explain on occasion an unexplained low serum chloride and high carbon dioxide combining power, the so-called hypochloremic alkalosis which may develop in these patients. All of these electrolyte changes must be watched for and properly interpreted so that intelligent treatment may be instituted.

Blood Proteins. The metabolism of proteins is greatly altered in the patient with a gastrojejunocolic fistula. The intake of food is usually inadequate. The food ingested is subjected to abnormal digestive processes and absorption manifested by low serum proteins and frequently a reversed albumin-globulin ratio.

Stools. The examination of the stools in the patient suspected of having a gastrojejunocolic fistula aids greatly in the diagnosis. Characteristically, the stools in a patient with a gastrojejunocolic fistula reflect the physiopathology of the abnormality. The stools are frequently yellow and contain a high quantity of fatty acids. Microscopically, fecal fat should be found in undigested or partially digested food particles. Stool examination for ova and parasites should also be made to eliminate other causes of diarrhea.

DIFFERENTIAL DIAGNOSIS

The weight loss and wasting associated with the gastrointestinal symptoms of gastrojejunocolic fistula frequently suggest a highly malignant intra-abdominal lesion. Indeed, the possibility must be kept in mind of the formation of a gastrojejunocolic fistula secondary to carcinoma of the transverse colon or stomach. In these cases, however, a history of previous gastric surgery is usually lacking

Furthermore, all types of gastrointestinal malignant disease are looked for and ruled out by roentgenologic studies, using the barium meal and the barium enema. Since the most characteristic symptom is diarrhea, gastrojejunocolic fistula must be distinguished from the various diarrheas. Again, the diagnosis of gastrojejunocolic fistula is confirmed by roentgenologic examination. If the fistulous tract is not demonstrated, bacteriologic and protozoic studies of the stool must be made for possible pathogens, ova and parasites which may explain the diarrhea. The diagnosis is usually made without difficulty from a careful history, examination and roentgenographic studies.

TREATMENT

The treatment of gastrojejunocolic fistula is primarily surgical. The medical aspects of therapy consist of preparing the patient for operation, and this will be discussed under preoperative care.

The surgical management of a large gastrojejunocolic fistula is technically difficult and often accompanied by considerable operative risk. The generally poor condition of these patients, the stage of malnutrition, the marked alteration in protein and blood chemistry findings make any extensive operative procedure, without measures to improve these states, entirely unsafe and, consequently, unwise. Most of these patients have had repeated abdominal operations, which have resulted in extensive adhesions and distortion of abdominal anatomy. This makes for time-consuming dissection to identify structures and establish anatomic relations before any restorative operative procedure can be carried out.

In an endeavor to avoid the high operative risk in these cases, numerous operative procedures have been suggested and employed by different surgeons. Experience has demonstrated that in order to prevent the recurrence of ulceration in any complicated ulcer case, a radical partial resection of the stomach should be employed, and that an ulcer is less likely to recur after resection. It is evident, therefore, that in addition to excision of the fistulous tract, a radical partial gastrectomy should be included in the operative plan. An extensive block dissection of the fistulous tract, however, in addition to a partial gastrectomy undertaken in one stage is entirely too hazardous to employ and would certainly result in a high percentage of fatalities. An operation designed to excise the fistulous tract and disconnect the stomach, jejunum and colon is undoubtedly the simplest form of surgical approach, but reestablishment of normal gastrointestinal continuity will result in recurrent ulcers in a large group of cases, and it is not to be recommended in the majority of cases. Furthermore, the induration and extent of the inflammatory induration may preclude any possibility of safely closing the rent in the colon or jejunum, and disconnection may compel the surgeon to proceed with extensive resection of the involved colon and jejunum, which immediately places the operation at a high risk level.

Simple excision of the fistulous tract and restoration of gastrointestinal continuity have been most often employed in groups of cases reported and it is with this type of operation that the mortality has ranged from 25 to 63 per cent. In addition, the tendency to recurrent ulceration profoundly influences the type of operation that should be employed for gastrojejunocolic fistula and a simple disconnecting operation, therefore, is not to be recommended because

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adds to the technical procedure of the first stage and increases the risk at a dangerous period of the patient's nutritional imbalance.

The first stage of operation for gastrojejunocolic fistula (Fig. 185) is as follows: The abdomen is opened through a left rectus incision. The involved areas of colon, jejunum and stomach are inspected and gently palpated, care being exercised to avoid separating adhesions in this area, which might possibly

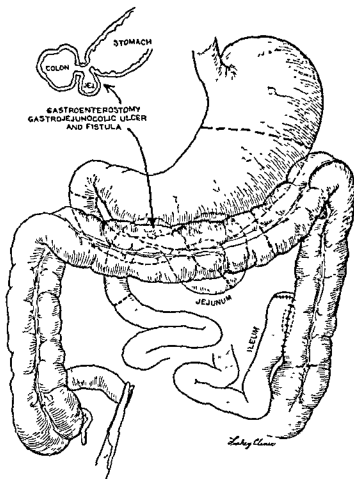


Fig. 185. First stage of operation for gastrojejunocolic fistula. The terminal ileum has been divided, the proximal end of ileum has been closed by inversion and a side-to-side anastomosis between the terminal ileum and descending colon has been established. The distal end of divided ileum is likewise closed by inversion and dropped back into the abdomen. The light segments indicate the portions of stomach, colon and jejunum which are to be removed at the second operation.

lead to leakage about the inflamed fistulous tract. The terminal ileum is identified and divided about 6 inches from the ileocecal valve, the mesentery being split sufficiently to permit approximation of the terminal ileum to the descending colon. The divided ends of the ileum are closed by inversion with layered sutures of catgut and silk. A side-to-side anastomosis of ileum to descending colon is then established and the abdomen closed in layers.

When the method was first used, the second stage was carried out about two weeks after the first stage. It early became evident, however, that a longer interval should elapse between stages in order that the patient's nutrition and general condition could improve. It is now an established practice to send these patients

of the high recurrence rate. In Walters'[8] series of 50 cases, most patients had a simple disconnecting operation and only 9 had an additional partial resection, yet the mortality in this group was 32 per cent. Finsterer[1] has preferred a one-stage operation for gastrojejunocolic fistula, but employed a two-stage operation if simple closure of the colonic fistula was impossible. He reported operation in 13 cases, with 5 deaths, a mortality of 38.4 per cent.

Because of the poor nutritional condition of patients with gastrojejunocolic fistula and because the operation in most instances involves long and tedious dissection, a two-stage procedure is to be recommended.

Pfeiffer,[6] in May, 1938, presented before the American Surgical Association an operative method employing a preliminary colostomy proximal to the fistula as a first-stage procedure. In 1941, he reported[5] a series of collected cases in which this plan had been employed, 10 patients had gastric resection in the second stage and 5 had simple excision of the fistula and restoration. One death resulted in this group, a mortality of 6.6 per cent.

This operation by Pfeiffer apparently reduces the operative hazard greatly and his mortality is the lowest yet reported with any operation designed to treat the serious complication of peptic ulcer. This method, however, presents certain technical problems which tend to complicate the operation and are, to a certain extent, undesirable. During the second stage, any extensive block dissection of the fistulous communication with additional gastric resection has to be carried out in the presence of a right colon fixed to the abdominal wall by virtue of the established colostomy and, also, in the presence of fecal contamination of the abdominal skin surface. Fixation of the colon adds to the difficulty of mobilizing the transverse colon, duodenum and pylorus in event of gastric resection. Soiling of the abdominal wall by a draining colostomy increases the hazards of abdominal wound and peritoneal infection. Moreover, on completion of the second stage, whatever it may be, the surgeon still has the colostomy opening to close, which adds to the extent of operation.

The operative procedure for treatment of gastrojejunocolic fistula employed at present at the Lahey Clinic, according to the plan suggested by Lahey,[2, 3, 4] was first used in April 1938. Since that date we have used this method in 28 cases, with 3 deaths, a mortality of 10.7 per cent. This operative plan consists of a two-stage procedure and employs the principle of block excision of the section of jejunum and colon involved, plus gastric resection. The first stage of the operation is designed to divert small intestinal and colonic contents from regurgitating into the stomach and jejunum. This is accomplished readily by dividing the terminal ileum and performing an ileocolostomy between the terminal ileum and descending colon. Small intestinal and right colon contents are thus emptied into the descending colon and cannot re-enter the stomach and jejunum. The toxic and irritating effects of such regurgitation are thus avoided, and these patients have tended to improve in nutrition, gain in weight and in most instances have complete cessation of diarrhea. If the diarrhea does not completely cease, the number of stools per day is greatly reduced in all cases. It is important that the first stage of the operation be as simple as possible, because it is at this stage that the patient's condition is at its poorest. The right colectomy should not be undertaken during the first stage because it materially

adds to the technical procedure of the first stage and increases the risk at a dangerous period of the patient's nutritional imbalance.

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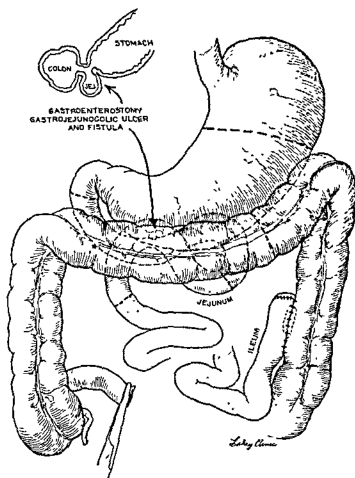


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When the method was first used, the second stage was carried out about two weeks after the first stage. It early became evident, however, that a longer interval should elapse between stages in order that the patient's nutrition and general condition could improve. It is now an established practice to send these patients

home for a period of two or three months before completing the operation by the second-stage procedure. A diet high in vitamins, protein and calories is given during this interval. Marked gain in weight is usual and one patient gained as much as 40 pounds between stages. Marked improvement in general condition was noted in all cases.

The second and final stage of the operation for gastrojejunocolic fistula is as follows (Fig. 186): The abdomen is again opened through a left rectus incision

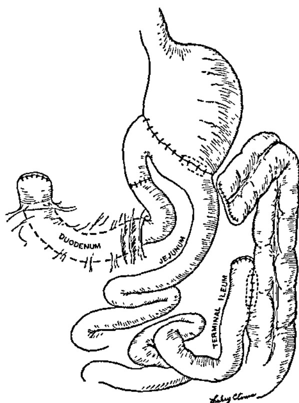


Fig. 186. Second stage of operation for gastrojejunocolic fistula. Drawing illustrates the completed operation. Note that the right colon and transverse colon to a point past the fistula, together with the portion of the jejunum involved with ulcer, have been resected. A gastric resection completes the operation.

which extends from the costal margin to a level below the umbilicus. The cecum, right colon and transverse colon are mobilized to a point distal to the colonic fistula. All mesenteric attachments are divided. The transverse colon beyond the fistula is then divided with the actual cautery between clamps, and the end of the distal portion of the transverse colon is inverted with catgut sutures, which are reinforced with interrupted silk sutures. The colon and attached stomach may then be turned forward and the involved loop of jejunum is readily visualized and likewise resected. A high resection of the stomach after mobilization and division of its attachment completes the block excision of the fistulous tract and involved viscera. An end-to-end jejunal anastomosis is carried out before completing the gastrojejunal anastomosis. The operation is extensive, but not nearly so formidable as it would appear. Mobilization and division of the colon permit easier mobilization of the stomach and ready resection of the jejunum.

All of these patients have been operated upon without shock, and the convalescence has been remarkably uneventful after such an extensive resection.

Our experience with 2 cases has been of especial interest. One patient, 47 years of age, who had had definite symptoms of gastrojejunocolic fistula for a period of a year, during which time he had lost 60 pounds in weight, reported immediate improvement following the first-stage operation of ileocolostomy. Four months after operation he had gained 21 pounds, diarrhea had completely ceased and he had been completely asymptomatic. Repeated examination after barium enemas have failed to show any colonic communication even though this could be readily demonstrated by barium enema before operation. Another patient, 53 years of age, who had symptoms of gastrocolic fistula of one month's duration and who had indisputable roentgenologic evidence of fistulous communication, apparently also obtained healing following the first stage. Barium enema has failed to show colonic communication and the patient is quite well. It should be emphasized, however, that the great majority of patients with gastrojejunocolic fistula will require the second-stage gastric resection and block excision of the fistulous tract in order to be completely free of all symptoms. In view of these 2 cases in which the fistula closed after the first stage, with marked improvement in nutrition and cessation of diarrhea and distress, roentgenologic examination should again be repeated in every case before the second stage of the operative procedure is carried out. Should examination fail to reveal the colonic fistula, no harm can result from deferring the second stage, provided the patient improves in health and provided repeated examinations fail to show the fistula.

PREOPERATIVE AND POSTOPERATIVE CARE

Preoperative Care. There is no preoperative problem relative to nutrition that is more difficult to treat than the patient with a gastrojejunocolic fistula. To establish a really satisfactory state of nutrition before operation is almost impossible although every attempt be made to do so. As the ingested nutrition either completely by-passes the large absorptive area of small bowel or passes through the small bowel rapidly, little absorption takes place. Consequently, dependence must be placed on parenteral feedings.

The first consideration is the replacement of fluids and electrolytes. Most of these patients, because of the diarrhea, are dehydrated and require large quantities of fluid. The amount to be replaced can be determined by the output. The insensible loss of fluid through the lungs and skin is estimated to be about 1000 to 2000 cc. every twenty-four hours. This amount added to the urinary output should be replaced by 5 per cent glucose in distilled water.

A record should also be kept of the amount of diarrhea. As mentioned previously, diarrhea contents contain large quantities of sodium, potassium, chloride and bicarbonate. The cation, sodium, however, is lost in excess of either the anions, chloride or bicarbonate. Therefore, the sodium must be replaced with both chloride and bicarbonate. This also prevents acidosis and helps the kidneys maintain proper acid-base balance. A convenient solution for this purpose is Hartmann's solution which contains sodium chloride, potassium chloride and,

in addition, sodium lactate. The lactate is metabolized to carbon dioxide and water and the sodium is used for replacement. We recommend that the amount of fluid estimated to be lost by way of diarrhea be equally replaced with Hartmann's solution.

It is also well to keep in mind the possibility of chronic potassium deficiency in these patients even though the serum potassium level and electrocardiographic changes are not indicative of such a deficit. It is wise to treat prophylactically such a possible deficiency by giving 2 to 3 gm. of potassium chloride in the daily infusions.

The second therapeutic consideration is to give, parenterally, sufficient calories. This is almost impossible as long as the fistula is present. The infusions of 5 per cent glucose barely contain the minimum requirements. Perhaps in the near future intravenous fats will be available so that large quantities of calories may be given parenterally in this form. Such a solution will be a great aid in these wasted patients.

An attempt is always made to replace proteins. The use of hydrolysates such as amigen or the use of amino acid solutions has been disappointing since these substances are usually burned as calories rather than used for the synthesis of body proteins. Blood and plasma are better sources of protein replacement. If serum proteins are greatly reduced, one of the best substances available to replace them is human serum albumin. In a period of two or three days the abnormal serum proteins may be elevated to normal values by giving frequent infusions of human serum albumin.

Anemia is always present and is treated most effectively by transfusion with large *quantities of whole blood. An attempt is always made to bring the* hematocrit, erythrocyte count and hemoglobin values up to normal. Frequently, because of wasting and dehydration, these values may be high and may not be a true index of the amount of blood to replace. Blood volume determinations would be of more value. Since blood volume determinations are not made in many hospitals, however, a working guide is to use about 40 cc. of whole blood for every pound of body weight lost.

The nutritional status of these patients is associated with severe avitaminosis. The avitaminosis is treated preoperatively with large doses of vitamin B complex and vitamins C and K. We routinely employ an ampule of solu B, 500 mg. of cevitamic acid and 72 mg. of hyquinone daily.

The ordinary methods of medically treating patients with marginal ulcer are of no particular value once a gastrojejunocolic fistula has developed. Morphine occasionally is of aid in treating the pain and diarrhea associated with the fistula, but there is no medical therapy which offers a cure to these patients since the effects are the result of altered intestinal mechanics.

The importance of careful preoperative preparation of these seriously ill patients cannot be overemphasized if a reasonable mortality and morbidity are to be expected after surgery.

Postoperative Care. Once these patients have had a satisfactory first-stage procedure, diverting the fecal stream away from the fistula, their nutritive state improves greatly. The diarrhea subsides almost immediately. Food is readily ingested, and absorption and digestive processes revert to normal. A few days

after operation the patients are placed on feeding regimens similar to those used for the treatment of patients with marginal ulcers. The patient's nutrition rapidly improves and in a period varying from one month to several months he is ready for the second-stage procedure. It is not uncommon during this interval for the fistulous tract to close and the marginal ulceration to heal partially. Most of these patients, however, should be subjected to resection of the stomach, jejunum and colon if permanent, satisfactory results are to be obtained. Preparation of the patient for the secondary stage and the care following resection are the same as the preoperative and postoperative care employed with gastrectomy.

SUMMARY

Gastrojejunocolic fistula is a serious complication of peptic ulcer and any surgical method of treatment will require an extensive operative procedure which may be extremely hazardous.

Careful preoperative and postoperative treatment should be employed to lower the incidence of this dreaded complication.

Surgical treatment of gastrojejunocolic fistula should consist of excision of the fistulous tract combined with a high gastric resection.

A two-stage operative procedure is recommended. A two-stage method employed in the Lahey Clinic is described. Results in 28 cases in which the operation has been employed are given.

The immediate operative mortality in the group of 28 patients was 10.7 per cent.

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SHOULD TOTAL GASTRECTOMY BE EMPLOYED IN EARLY CARCINOMA OF THE STOMACH

Experience with 139 Total Gastrectomies

FRANK H. LAHEY AND SAMUEL F. MARSHALL

Total gastrectomy has now been done over a sufficient number of years to make it worth while to attempt to evaluate its effectiveness and possible place in the radical treatment of gastric cancer. As has been proper up to now, practically all of the operations of total gastrectomy from which figures of five-year survival can be obtained have been done in cases in which the cancer of the stomach was too advanced to be completely removed by partial gastrectomy. In some of these cases, total gastrectomy had been employed for carcinoma of the stomach which involved the cardia or upper portion of the stomach in which, by an abdominal approach, the entire stomach with its tumor could be removed

Table 1. Total Gastrectomy—139 Cases

	PATIENTS	POSTOPERATIVE DEATHS	MORTALITY, PER CENT
1927–1943	75	26	34.6
1944–1950 (March 1)	64	6	9 4
	139	32	

and an esophagojejunal anastomosis made. It is of interest to note in the last ten years the development of total gastrectomy as a radical method for removal of cancer of the stomach and also to note the increase in the number of total gastrectomies being done in the later years as well as the significant general decrease in the operative mortality of this operation.

Finney and Rienhoff[4] reviewed the literature on total gastrectomy in 1929 and were able to report a total of 67 patients who had been subjected to this radical operative procedure, including 5 cases of their own. The operative mortality was 53.4 per cent, and in 58 per cent of those cases the cause of death was peritonitis. Our interest in total gastrectomy dates from 1927 when the first total removal of the stomach was done in this clinic. In 1938, 8 cases of total gastrectomy were reported from this clinic by one of us[5] (F. H. L.) with 3 postoperative deaths. In 1944,[7] 65 additional cases, making in all 73 cases, were reported, with an operative mortality of 33 per cent. This report was compiled in November, 1943, and did not include 2 cases in which total gastrectomy was done shortly after the paper was submitted for publication, making a total

Originally published in Annals of Surgery, 132.540–560 (Sept.) 1950 J. B. Lippincott Co, publishers

of 75 cases of total gastrectomy up to the end of 1943 (Table 1). We have now done 139 complete gastrectomies, of which 127 were for malignant tumors of the stomach and 12 for benign gastric ulcer (Table 1). From January 1, 1944, to March 1, 1950, 64 total gastrectomies have been done, with 6 postoperative deaths, an operative mortality of 9.4 per cent, whereas there was 1 death in a group of 12 total gastrectomies for peptic ulcer, an operative mortality of 8.3 per cent. It is apparent that a sufficient number of total gastrectomies have now been performed to demonstrate that the mortality of total gastrectomy can be brought within the same range as partial gastrectomy. It is evident from our figures for 1944 to 1950 that the operative mortality of total gastrectomy is now no higher than that of partial gastrectomy. The mortality of partial gastrectomy for malignant disease of the stomach from 1937 to July 1949 was 9.2 per cent.

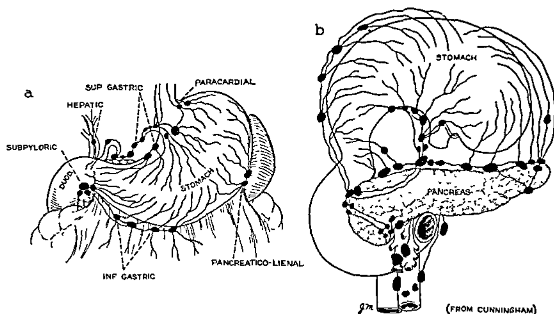


Fig. 187. Note the node distribution of the stomach and how incomplete in terms of radicalness any operation short of total gastrectomy is for cancer of the stomach. *a*, Lymph nodes over anterior surface of stomach and omentum. *b*, Stomach elevated to show lymph nodes of posterior surface.

Numerous articles in the recent surgical literature record decreasing mortality rates for total gastrectomy. Farris, Ransom and Coller[3] reported only 2 deaths in a consecutive series of 19 cases, a mortality of 10.5 per cent. Scott and Longmire,[13] in reporting on 63 cases of total gastrectomy in 1949, gave a mortality rate of 9.5 per cent. At present, however, figures on survival rates after total gastrectomy are too small and the number of cases of total gastrectomy is still not sufficiently large to make worth-while comparison with the results obtained following partial gastric resection for carcinoma, nor could the analogy be made upon truly comparable groups of cases, since total gastrectomy has up to the present time been employed almost exclusively in the more widespread type of gastric malignancy too extensive to permit the use of partial gastrectomy.

In view of this satisfying lowered mortality rate now accompanying total gastrectomy for the treatment of late gastric cancer, one of us[6] (F. H. L.) in a recent editorial stated that the time is now at hand to consider a more aggressive

surgical approach to the treatment of intermediate and early gastric malignancy with the hope that we may thus improve the five-year survival rate which, with partial gastrectomy, is now so deplorably low. As shown in Figure 187, total gastrectomy for cancer, when compared with other radical operations for cancer, does more satisfactorily fulfill the requirements of radical removal of the lesions and the adjacent nodes than does subtotal gastrectomy. Pack and McNeer[12] have recently quite properly emphasized the fact that any improvement in our results of the treatment of gastric cancer will be obtained only by increasing the resectability rate and by resecting all gastric cancers that are technically removable. This, of course, would mean not only wide extirpation of the gastric cancer itself and its lymphatic distribution but also the radical removal of any involved adjacent organs. That partial gastrectomy has resulted in a very low five-year survival rate is illustrated by the 20 per cent five-year survival rate in resected cases reported by Welch and Allen.[16] Our own five-year survival rate is similar, 22.3 per cent of those patients who survived resection. Pack and McNeer[12] reported that 34.7 per cent of 75 patients surviving partial gastrectomy lived five years without recurrence. When one considers that approximately only 1 in 4 of those patients who come to surgery with the diagnosis of cancer of the stomach can have a resection, the survival rate for the entire group that enters the hospital is very low indeed. During the period 1936 to 1940 in this clinic only 24.1 per cent of the patients operated upon for cancer of the stomach had resection, but since that period we have gradually increased the resectability rate in these cases to 37 per cent (1940–1945).

Inasmuch as total gastrectomy has been done in many cases in which the lesion involves the upper half of the stomach or the gastric cardia it is of interest to compare these results and note the operative mortality associated with the transthoracic approach to this problem. Sweet,[14] in 1948, reported 86 cases of gastric carcinoma invading the cardia and lower esophagus in which resection and primary anastomosis were done with 10 deaths, a mortality of 11.6 per cent. In the same year, Pack and McNeer[11] reported 65 cardiectomies with an operative mortality of 32 per cent. In the majority of this latter group resection was done by the transthoracic approach.

In any discussion of total gastrectomy there will always arise the discussion about whether or not total gastrectomies should always be done through the chest. This question will never be completely settled. Our position on it is that when there is any question about extension beyond the diaphragm, it should be approached transthoracically and when the esophagus can be demonstrated as free, we prefer the abdominal route. Our inclination is toward the abdominal route, because in few of the patients with carcinoma of the stomach which has extended upward along the esophagus will the tumor prove to be operable. In addition, we prefer the abdominal approach because it is easier for us to do low resections of the duodenum close to the common duct by this approach and also because in occasional cases we have had to remove the left half of the pancreas, the transverse colon or the left lobe of the liver when those structures have been involved in the growth by direct contact.

In the light of our present knowledge the only available method of treatment for cancer of the stomach is radical surgical removal. The early diagnosis of

cancer of the stomach has not appeared to improve very much over the past few years. However, if more attention could be paid to digestive complaints in patients over the age of 45, an earlier diagnosis would be possible in a much larger group of these patients. It is significant to emphasize that the annual death rate for cancer of the stomach in 1945 was 11 per 100,000 for all persons from 1 to 74 years, whereas between the ages of 45 and 74 the annual death rate for cancer of the stomach was 53.7 per 100,000.[9] It is also of considerable significance to point out that of the total deaths each year, approximately 13.5 per cent are

Table 2. Total Gastrectomy for Malignancy—127 Cases

SEX		AGE, YEARS	
Males	77	20–30	2
Females	50	31–40	7
	—	41–50	29
	127	51–60	42
		61–70	34
		71–80	13
			—
			127

caused by cancer in all its forms, whereas 3.1 per cent of the total number of deaths were from cancer of the stomach. Cancer of the stomach is the most common form of malignant disease. This is particularly true in males past the age of 45.

In this group of 127 patients having total gastrectomies for carcinoma, 77 were males and 50 were females (Table 2), which is about the proportion given by the United States Bureau of Vital Statistics for carcinoma of the stomach in males and females, a ratio of 20 to 12. In this group of 127 patients with gastric cancer who had had total gastrectomy, 92 per cent were above the age

Table 3. Duration of Symptoms (127 Cancer Cases)

SYMPTOMS		PATIENTS
Less than 3 months		42
3 months or more		85
3 to 6 months	18	
6 to 9 months	31	
9 to 12 months	6	
1 year or more	30	
		—
		127

of 40 (Table 2), the youngest being 27 years of age and the oldest 78. A discouraging feature in regard to the early diagnosis of this lesion is the duration of symptoms before a patient seeks medical aid or before the diagnosis is established. Of the group of 127 patients who had total gastrectomies done for gastric carcinomas, 42 patients had had symptoms for three months or less and 85 had had symptoms for from three months to a year or more (Table 3). Thirty patients had had considerable gastric distress for a year or more. Among the

patients who had symptoms for three months to a year or more the delay was the responsibility of the physician in 53 cases, either because of a lack of diagnosis or an erroneous diagnosis, and was due to the patient's failure to seek medical aid in 32 cases (Table 4). The relationship of benign gastric ulcer to the development of gastric cancer is something which has concerned every surgeon operating upon many patients with gastric cancer. Fifteen patients had a history for several years which was strongly suggestive of untreated ulcer, and

Table 4. Delay in Treatment

	PATIENTS	
Delay due to		
Physician	53	
Patient	32	85
No delay (symptoms less than 3 months)		42
Total		127

26 patients actually had been treated for ulcer over long periods without roentgenologic examinations; 5 patients had been treated for primary or secondary anemia (Table 5). There were only 42 patients in the entire group who had had symptoms for less than three months, which we think justified classification as no delay in diagnosis, as they presumably came for diagnosis and treatment within a fairly reasonable period. It is quite apparent, in the study of these cases, that the correct roentgenologic diagnosis is related to the skill and experience of the roentgenologist.

Table 5. Delay in Surgical Treatment Three Months or More from Onset of Symptoms—127 Cases

CAUSE	PATIENTS
Ulcer history—untreated	15
Treated for ulcer	26
Primary or secondary anemia (treated)	5

As one studies the histories of these cases, one's attention is constantly called to the necessity for greater wariness concerning all digestive disorders in patients past the age of 45. In this group of cases (Table 6) the most common earliest symptom noted was epigastric pain or discomfort which occurred in 79 patients. The most common symptoms which were noted in all of these cases (Table 7) were pain, weight loss and anorexia, and those patients who had neoplasms which were far advanced when seen by the physician complained more frequently of nausea and vomiting, malnutrition and anemia.

Even granting that total gastrectomy was done in practically all of these cases for advanced or widespread malignant disease involving the greater portion of the stomach (Table 8), anemia was not an outstanding sign or symptom, as there were only 29 patients with a hemoglobin of less than 75 per cent and 21 patients with a red count of less than 4,000,000. Determination of the gastric

acids was not particularly significant; 50 patients had no free hydrochloric acid in their gastric contents and 23 patients had less than 20. From these figures it can again be emphasized that in a patient with gastric symptoms an achlorhydria is of great significance and may well indicate gastric neoplasm, whereas

Table 6. Total Gastrectomy for Carcinoma—127 Cases; Earliest Symptom Noted in Individual Cases

SYMPTOM FIRST NOTED	CASES
Epigastric pain or discomfort	79
Anorexia	11
Dysphagia	9
Flatulence	7
Nausea or vomiting	8
Bleeding	5
Hematemesis	
Melena	
Anemia	3
Pallor	
Weakness	
Weight loss	4
Diarrhea	1
	127

the presence of free hydrochloric acid, as is well known, is no assurance of the absence of malignant disease in the stomach.

Table 7. Total Gastrectomy—127 Cases of Carcinoma; Symptoms in Order of Frequency

Pain	99	Vomiting	21
Weight loss	98	Bleeding	11
Anorexia	54	Hematemesis	
Flatulence	31	*In stool*	
Nausea	22	Dysphagia	10
		Anemia	5

One of the most common and also variable characteristics of malignant tumors is their ability to metastasize to regional lymph nodes. The extent of such lymph

Table 8. Total Gastrectomy for Carcinoma—127 Cases; Laboratory Data

	CASES
Gastric contents	
No free hydrochloric acid	50
Free hydrochloric acid less than 20	23
Anemia	
Hemoglobin less than 75%	29
Erythrocytes less than 4,000,000	21

node involvement is considered a quite reliable criterion on which to base the prognosis in an individual case. This has been of considerable prognostic significance in carcinomas of the intestine and of the breast. Recently, Moore[10] and

his associates have suggested that the lymph node involvement from cancer of the stomach might be of some prognostic significance in those cases, and they thought that the presence or absence of demonstrable metastases in the regional lymph nodes has great prognostic value. They reported that in 100 patients surviving resection, 29 lived three years and 13 lived five years; 71.4 per cent of those without involvement of lymph nodes lived three years or longer, whereas only 17.7 per cent with involvement lived three years or longer. In our group of 127 patients who had total gastrectomy, 83, or 65.4 per cent, had involvement of lymph nodes, and only 44, or 34.6 per cent showed no metastases to lymph nodes. It will be shown later in Table 13 that this was of some significance in the ultimate survival, as a somewhat larger group of patients survived for longer periods when there was no involvement of lymph nodes than did those with node metastases.

Meissner[8] (pathologist at the New England Deaconess Hospital), however, believes that many gastric cancers are being resected early so far as lymph node

Table 9. Length of Survival in Patients With Extension of Carcinoma Near or Through Line of Resection—12 Cases

	CASES
Postoperative deaths	3
Lived less than 6 months	2
Lived 6 months or more	4*
Lived 1 year	1
Lived 1½ years	1
Lived 2 years	1
Total	12

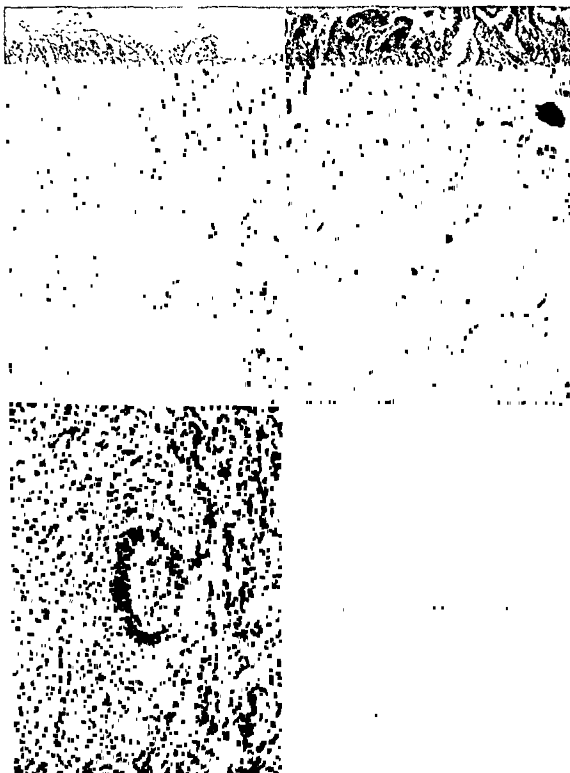
* 3 lived six months; 1 lived nine months.

metastases are concerned, but that other evidence of malignant spread is of equal importance in determining the ultimate survival of the patient. These observations of Meissner were made in the New England Deaconess Hospital, Laboratory of Pathology, where all the resected gastric specimens of this clinic undergo careful pathologic examination. He studied 100 resected specimens of carcinoma of the stomach and believed that factors other than metastases to lymph nodes are of great importance in determining the ultimate course of gastric cancer. These factors, he has suggested, are diffuse lymphatic invasion (Fig. 188) through the various layers of the stomach, and involvement of the duodenum (Fig. 189) and blood vessel invasion (Fig. 190). He found blood vessel invasion present in 57 per cent of the cases and this vascular infiltration showed no relation to the extent of involvement of lymph nodes. He was impressed with the frequency of diffuse lymphatic spread which will take place with little demonstrable lymph node involvement and may not be recognized grossly. That this lymphatic spread may extend across into the duodenum as well as above the proximal line of resection (Table 9) in subtotal gastrectomy has not been sufficiently emphasized (Fig. 191).

Coller, Kay and McIntyre,[2] in a study of lymphatic invasion in 53 cases, found that the gastric carcinoma had involved the duodenum in 26.4 per cent.

Fig. 188.

Fig. 189.



The upper margin of the extension of the gastric cancer in their group could not be determined by gross appearance alone.

Castleman[1] has also emphasized that submucosal lymphatic invasion may extend across the pylorus and involve the duodenum as well as to the proximal level of the gastric resection in subtotal gastrectomy. He reported 21 cases of gastric carcinoma in which invasion of the duodenum varied from 4 to 23 mm. beyond the pylorus. It is possible frequently, then, when subtotal gastrectomy is done, to find neoplastic tissue microscopically at both margins of the surgical resection, upper and lower, in what usually appears as normal tissue beyond the gross neoplasm. In our group of 127 patients with gastric neoplasms treated by



Fig. 191 Esophagojejunostomy. *a*, One and one-half years after total gastrectomy. *b*, Same patient two and one-half years after operation. Patient is alive and well. Tumor was carcinoma simplex with extension by lymphatic spread, most of the nodes were involved.

total gastrectomy, such diffuse submucous lymphatic spread was noted in 12 cases (9.5 per cent) in which extension of the carcinoma near or through the line of resection was found microscopically in spite of the fact that the level of resection of the stomach had been carried through apparently grossly uninvolved tissue. Of the 12 cases with such diffuse lymphatic spread there were, as would be expected, 3 postoperative deaths, and 2 patients lived less than six months, 4 lived six months or more; only 3 patients survived longer than nine months, one for a year, one for a year and a half and one for two years. It is to be remembered that practically all of these 127 patients in this series in whom total gastrectomy was done had very advanced lesions and that when the operation is limited to such advanced lesions, submucosal spread will frequently be encountered.

Shields Warren[15] has reported 23 instances (19.6 per cent) of recurrent carcinoma in the gastric stump in autopsies on 122 patients who subsequently

died from recurrent disease following partial gastric resection for malignancy. While it is conceded that a wide margin of normal gastric wall and duodenum should be included in gastric resection for carcinoma of the stomach, if this submucosal spread can occur in what appears to be normal duodenal or stomach wall, how can one ever be sure of the safe line for resection in partial gastrectomy? Partial gastrectomy is obviously not an extensive enough resection to offer the best chance of removing all of the malignancy in the greatest possible number of cases of gastric cancer.

From time to time we have published our methods of doing total gastrectomy, and many points regarding the technic of total gastrectomy have been published by many others. How one does it is not as important as the adequate removal of the gastric malignancy together with all of its involved lymph nodes. Coller et al. and Meissner have shown that *it is not enough to remove only palpable* nodes or enlarged nodes but that all lymphatic drainage areas of the stomach should be included in the resection, something which we believe can be accomplished only by a total gastrecomy, which should include splenectomy.

THE EXTENT OF THE OPERATION

If total gastrectomy is to be applied to cancers of the stomach early or late it should be of the most radical type (Table 10). To fill this requirement it

Table 10. Total Gastrectomy—139 Cases

		PATIENTS
*A.	Total gastrectomy with splenectomy and jejunojejunostomy	63
B.	Total gastrectomy with splenectomy	33
C.	Total gastrectomy with jejunojejunostomy	23
D.	Total gastrectomy only	20
		139

* 5 patients in Group A had resection of adjacent viscera—colon, pancreas, liver—with 1 death.

should include the removal of the duodenum at the lowest possible level without involving the point in the duodenum where the common duct enters it. Since, as already stated, submucosal spread onto the duodenum is not uncommon and one will not know the extent to which this spread has taken place until a specimen is examined microscopically, radical removal of the duodenal stump to the lowest possible level is an important step in the accomplishment of this aggressive procedure. All of the gastrohepatic omentum, attached to the lesser curvature, should be carefully removed with the stomach, after the gastric artery is tied as close to its origin as possible. The great omentum should be separated carefully from its point of origin on the hepatic flexure to well past the splenic flexure and up to the lower pole of the spleen. The spleen should be included with the stomach because of the drainage of the lymphatic channels along the greater curvature into the group of nodes in the omentum between the greater curvature and the splenic hilum, as shown in Figure 187. The chain of nodes running on either side of the esophagus up into the hiatus in the diaphragm should be carefully wiped down, all of the vagus fibers cut, and the wall of the esophagus

The upper margin of the extension of the gastric cancer in their group could not be determined by gross appearance alone.

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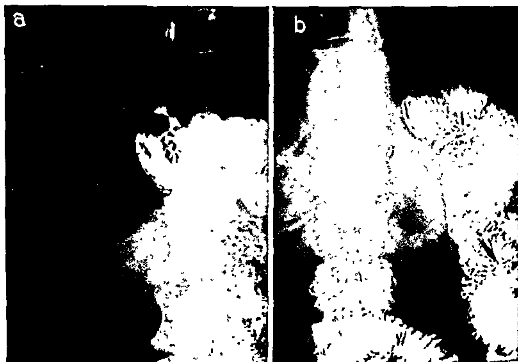


Fig 191. Esophagojejunostomy. *a*, One and one-half years after total gastrectomy. *b*, Same patient two and one-half years after operation. Patient is alive and well. Tumor was carcinoma simplex with extension by lymphatic spread; most of the nodes were involved.

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further steps in the procedure are unjustified. If the pelvis is negative, the next step is to turn up the transverse colon and inspect its root in the jejunal fossa. Not infrequently, even though the lesion from the front view and from palpation

Fig. 193.

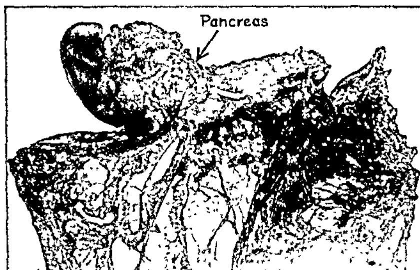




Fig. 193. The direct involvement of the left half of the pancreas by the carcinoma of the stomach and the removal of the left half of that structure are shown. When adjacent organs have been involved only by direct invasion and are removable with the stomach we have not hesitated to do so.

Fig. 194.

Fig. 194 Entire stomach removed with omentum and spleen. Patient lived seven years and died of recurrent carcinoma. This specimen demonstrates that total gastrectomy fulfills the requirements for a really radical operation for cancer of the stomach. It *removes all* of the involved organs, a good section of the duodenum, the gastrohepatic omentum, the spleen with the group of nodes between it and the greater curvature and all of the node-bearing great omentum.

seems operable, with this exposure it will be found to have invaded the mesenteric root to such an extent that continuation of the procedure will be unwise. If the lesion has not involved the root of the transverse mesocolon, one next separates the omentum from the transverse colon as shown in Figure 192, so that the entire lesser peritoneal cavity is exposed. In those cases in which there is doubt as to the wisdom and justification of employing total gastrectomy in cancers of the stomach, there is no single step by means of which one can settle

carefully wiped downward to free it of the lateral chain of nodes, as shown in Figure 187, attached to it. The esophagus should be mobilized well down from the hiatus after the vagus fibers have been cut, and frequently a distance of 10 to 12.5 cm. of esophagus can be so mobilized. With such an extensive removal of the stomach and its adjacent node-bearing area, a really aggressive and radical operation for cancer can be done.



FIG. 192. This drawing illustrates complete detachment of the omentum from the colon and stomach turned up to visualize completely the lesser peritoneal cavity. In cases in which operability is doubtful this exposure makes it possible to decide operability or inoperability of the lesion. If the lesion proves inoperable because of its demonstrated spread, the operation can still be terminated even at this point with no ill effects.

One of the important steps in the employment of total gastrectomy for gastric cancer is the determination of operability. This can best be accomplished by a series of investigations performed in sequence. When the abdomen is first opened, one can, particularly in advanced lesions, settle inoperability merely by palpating the lesion, as when the lesion is firmly fixed and when there are obvious metastases to the liver. In less extensive lesions, however, the determination as to whether or not total gastrectomy in such a case is justifiable is often not easy to settle. If the lesion seems operable, the first step is to investigate the pelvis for the possibility of gravity metastases and if they are present, obviously

further steps in the procedure are unjustified. If the pelvis is negative, the next step is to turn up the transverse colon and inspect its root in the jejunal fossa. Not infrequently, even though the lesion from the front view and from palpation

Fig. 193.

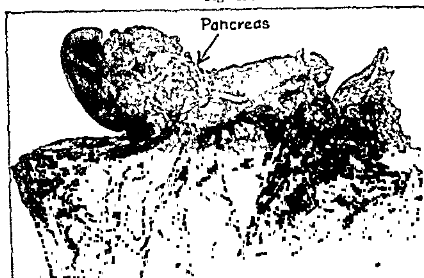




Fig. 193. The direct involvement of the left half of the pancreas by the carcinoma of the stomach and the removal of the left half of that structure are shown. When adjacent organs have been involved only by direct invasion and are removable with the stomach we have not hesitated to do so.

Fig 194.

Fig. 194. Entire stomach removed with omentum and spleen. Patient lived seven years and died of recurrent carcinoma This specimen demonstrates that total gastrectomy fulfills the requirements for a really radical operation for cancer of the stomach. It removes all of the involved organs, a good section of the duodenum, the gastrohepatic omentum, the spleen with the group of nodes between it and the greater curvature and all of the node-bearing great omentum.

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whether or not total gastrectomy can be wisely employed that is comparable with complete separation of the omentum and the transverse colon and the complete exposure of the entire lesser peritoneal cavity. With this exposure, should the lesion be demonstrated as extending into the pancreas and beyond, one can terminate the operation by dropping the omentum back into the abdomen and leaving the lesser peritoneal cavity widely open with no disadvantage. With this exposure, invasion of the pancreas can be demonstrated and feasibility of resecting the tail and body of the pancreas when it is involved by direct contact with the lesion can be demonstrated (Fig. 193). When the lesion is in the prepyloric region and has involved the head of the pancreas it can be plainly demonstrated and its inoperability clearly determined. With this wide exposure and with the stomach turned up, the extent of involvement of nodes around the celiac axis and into any retroperitoneal tissue can be plainly demonstrated.

In our early cases of total gastrectomy, no attempt was made to remove the spleen or to do a jejunojejunostomy (Table 11). Our present-day plan consists

Table 11. Survival—37 Cases of Carcinoma; Splenectomy Not Done

	CASES
Postoperative deaths	15
Lived less than 6 months	2
Lived 6 to 12 months	2
Lived 1 to 2 years	9
Lived 2 to 3 years	1
Lived 3 to 4 years	2
Lived 5 years or more	5—14%
	36

These were the earliest cases done before splenectomy was routinely employed.

not only in the wide removal of all involved lymph nodes but also in the removal of the spleen (Fig. 194) and the performance of a jejunojejunostomy to prevent the bathing of the esophagojejunal anastomosis with the bile and pancreatic juices, which often results in the production of an esophagitis with dysphagia and substernal pain.

We wish particularly to call attention to a procedure developed by one of us (S. F. M.) by means of which it has been possible to leave in place a soft, indwelling Penrose tube (Fig. 195) through which the patient can be fed for the first few days after operation. As can be seen in this illustration, the Levin tube which is passed through the anastomosis is brought down to the point where the entero-enterostomy is done, the Penrose tubing is tied to the end of a Levin tube, and the Levin tube, as it is withdrawn through the nose, pulls the soft Penrose tubing through with it, leaving thus a small, hollow tube of soft rubber, nonirritating to the nose, through which fluids and food can be introduced.

MORTALITY

From 1927 to 1943 there were 75 cases of total gastrectomy, with 26 deaths, an operative mortality of 34 6 per cent. From 1944 to the present date there have been 64 total gastrectomies with 6 postoperative deaths, a mortality of 9.4 per

cent. The cause of death in each group is given in Table 12. It is relevant that postoperative death in the majority of cases in the first group was due to sepsis, such as mediastinitis, peritonitis or pneumonia; 22 of the 26 deaths (85 per cent)

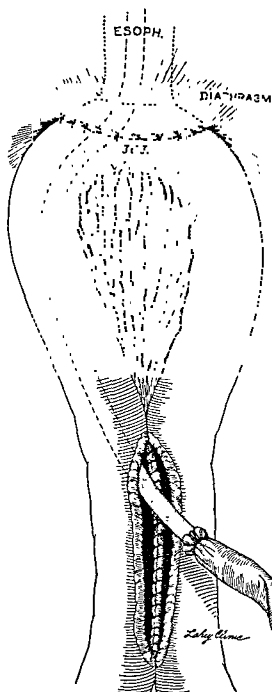


Fig 195. Esophagojejunostomy and entero-enterostomy. Note thin rubber Penrose tubing tied to the lower end of the Levin tube to be withdrawn through esophagus and out of the nose to permit early feeding, thus making jejunostomy unnecessary.

were on the basis of some type of sepsis. In the group of cases since 1944 in which the mortality has been so markedly decreased, only 2 of the 6 deaths were due to sepsis or peritonitis.

Tables 13, 14 and 15 give the length of time that these patients with total

Table 12. Total Gastrectomy—139 Cases; Causes of Postoperative Deaths

CAUSE OF DEATH	CASES	
1944–1950—64 Patients—6 Deaths		
Embolism	1	
Peritonitis	2	
Cardiovascular disease	3	
1927–1943—75 Patients—26 Deaths		
Cardiovascular disease	3	
Embolism	1	
Mediastinitis	2	Sepsis, 2
Peritonitis	17	
Pneumonia	3	
	26	

Table 13. Total Gastrectomy: Carcinoma—127 Cases

	NO METASTASES IN LYMPH NODES 44 CASES (34.6%)			METASTASES IN LYMPH NODES 83 CASES (65.4%)		
	Living and Well	Alive with Recurrence	Dead	Living and Well	Alive with Recurrence	Dead
Postoperative deaths			12			19
Survived						
Less than 12 months	5	1	4	4	..	27
1–2 years	3	..	3	2	1	17
2–3 years	2	..	2	1	..	3
3–4 years	..	..	2	..	..	2
4–5 years	2	..	..	1	..	2
5–6 years	2	..	2	1	..	..
6–7 years	..	..	1	..	..	..
7–8 years	1	..	..	..	..	..
8–9 years	..	..	..	..	..	..
9–10 years	..	..	..	2	..	..
10–11 years	..	..	..	..	..	..
11–12 years	1	..	..	..	1	..
12–13 years	1	..	..	..	..	..
	17	1	26	11	2	70

Table 14. Survival After Total Gastrectomy for Cancer—127 Cases

	CASES
Postoperative deaths	31
Survived	
Less than 1 year	41
1 to 2 years	26
2 to 3 years	8
3 to 4 years	4
4 to 5 years	5
5 years or more	12
	127

12.5 per cent lived 5 years or longer
21.9 per cent lived 3 years or longer

gastrectomy for carcinoma have survived operation (Figs. 196 and 197). The survival rate is much less in those cases in which the lymph nodes were involved than in those cases in which there were no nodal metastases (Table 13). Of the 127 patients, 33 out of 83 patients (40 per cent) with involvement of lymph nodes survived one year or more, whereas 22 of 44 patients (50 per cent) with negative lymph nodes lived one year or more. It must be recalled that these figures were obtained in those cases of cancer of the stomach in which the lesion was too advanced for partial gastrectomy and in cases which in the past had been considered relatively hopeless. Twelve patients of the group of 55 (22 per cent) surviving one year were alive and well five years or more following total gastrectomy. While this salvage rate is low, it is not uncheering in such an advanced group of cases, and it is not unreasonable to anticipate improvement in these figures if this radical surgery is attempted in early gastric carcinoma.

In the light of the figures presented in these tables and as a result of this not inconsiderable experience with total gastrectomy, largely in patients with advanced malignancies of the stomach, it does not seem unreasonable to suggest

Table 15. Patients Now Living After Total Gastrectomy for Cancer

	CASES
Less than 12 months	10
1 to 2 years	6
2 to 3 years	3
4 to 5 years	3
5 years or more	9
	31

that we may very well improve our results if this operation of total gastrectomy is employed in the earlier forms of malignant diseases of the stomach, in a comparable way, as radical procedures are employed in cancers of the rectum, the colon, the thyroid and of the breast. As one of us has stated in an editorial[6] (F. H. L.), with such a radical approach one has everything to gain and, in view of the present low five-year survival rate, very little to lose. As pointed out in this editorial, total gastrectomy is a difficult operation, requiring anastomosis of the jejunum to the esophagus under the ribs where accurate suture requires great care and gentleness. It is an operation that requires adequate and complete relaxation which can be obtained only by good anesthesia. It is an operation often quite shocking in character and one which must be done on patients some of whom are fat and some of whom are in poor states of nutrition. It is for this reason that we feel obligated here to repeat a warning which was included in the aforementioned editorial, namely that it will require considerable discrimination on the part of surgeons operating upon patients for cancers of the stomach as to their capacity to apply this operation to patients with early cancer of the stomach, the place where, as we have suggested, this procedure has the greatest possibility of improving our quite unsatisfactory results obtained with the less radical procedure of subtotal gastrectomy.

There are some real problems which result from the complete removal of the stomach, but these are not insurmountable. Life can be satisfactory without a





Fig. 196. Total gastrectomy for malignant tumor, patient alive and well 13 years since operation. *a*, Prior to total gastrectomy; *b*, esophagojejunal anastomosis.

Fig. 197. Esophagojejunostomy; total gastrectomy performed for carcinoma simplex. Patient alive, well and working ten years after operation.



Fig. 198. Esophagojejunal anastomosis after total gastrectomy for malignant tumor. *a*, Contraction and obstruction of lower end of esophagus at anastomosis; *b*, after dilatation of the obstruction. Patient is well; no dysphagia present.

stomach, patients can be comfortable, can have a feeling of physical well-being, can eat reasonably well and attain a reasonable economic status. One must expect some difficulties in nutrition in these cases. We doubt if a patient can ever become obese after a total gastrectomy and sometimes thin individuals have had a quite difficult time in gaining weight or even in maintaining their weight. Most of them have had a fair appetite but are quickly satisfied with a small amount of food, or may develop slight discomfort while eating which causes them to limit their food intake. The principle of frequent feedings of comparatively small amounts of high caloric foods is the obvious answer to this particular problem. These patients are advised to follow a six-meal schedule rather than a three-meal schedule.

Because of the loss of the macerating or softening process normally performed by the stomach, some attention must be given to the physical character of the food eaten. If the patient has good teeth and is careful to chew his food, usually it is not necessary to do much more about this aspect of the diet. Patients who have poor teeth and who are likely to eat hurriedly should eat food which is mechanically finely divided and is reasonably soft in texture so that it can be readily accepted by the jejunum.

Some of these patients, as would be expected from this rearrangement of the alimentary tract, are troubled by the well-known "dumping" syndrome and symptoms develop, such as excessive fullness, a sense of weakness, sweating, nausea and palpitation which occur immediately after ingestion of food. This has best been managed by frequent small feedings with attention to the limitation of fluids. Usually solid food is better tolerated than fluids, and cold liquids are particularly likely to bring about distress. These patients obtain considerable relief from these symptoms by lying down for a few minutes immediately after eating. We have not considered it rational to give these patients hydrochloric acid because they do not have any pepsin to be activated by the acid. We have not been convinced that it is necessary to give them any pepsin or any digestant to take the place of the loss of gastric juice so far as digesting the food is concerned.

Some of these patients following total gastrectomy occasionally experience some dysphagia and difficulty with eating, due apparently to narrowing and spasm of the esophagojejunal stoma, and some of them have had to have dilatations done by bougie. Some patients even without demonstrable obstruction have had periodic episodes of dysphagia and regurgitation of esophageal mucus. It has, at times, been a troublesome complication. If definite obstruction is shown to be present by roentgen examination of the esophagus or by esophagoscopy, dilatation by bougie can readily be done and will in most instances correct the dysphagia (Figs. 198 and 199). In this group of 139 cases in which total gastrectomy was performed, dilatation of the opening of the esophagus into the jejunum was necessary in 42 patients. One should not conclude because of swallowing difficulty or dysphagia that the patient has recurrent carcinoma. To establish the presence or absence of recurrent carcinoma at the esophagojejunal anastomosis, when obstruction occurs esophagoscopy can be done and a biopsy specimen obtained after dilatation.

The hematologic complications that arise following total gastrectomy vary considerably from patient to patient. The most common early postoperative mani-

festation—and very often this may take several years to develop—is a hypochromic state due to an iron deficiency. This is easily treated with normal therapeutic doses of ferrous iron. At a somewhat later stage after total gastrectomy a macrocytic megaloblastic type of anemia may develop which readily responds to treatment with liver extract. Sometimes these two types of anemia may develop

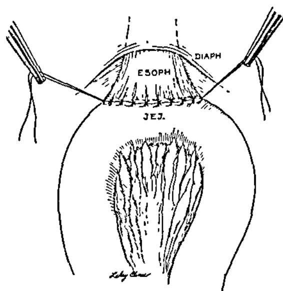


Fig. 199. Esophagojejunostomy. Traction sutures are placed at angles of anastomosis to prevent narrowing during suturing of jejunum to esophagus. This trumpets the end of the esophagus and serves to prevent later stenosis and obstruction.

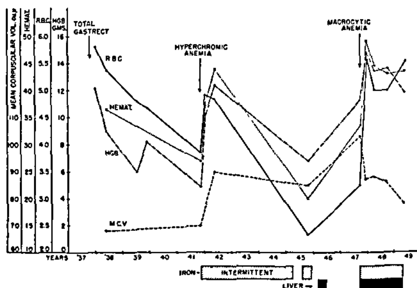


Fig. 200. Hematologic data following total gastrectomy. Note the slow development of hypochromic anemia following operation, with normal response to medication with iron. Years later a macrocytic anemia developed, the blood picture rapidly returned to normal following therapy with liver and iron.

simultaneously and occasionally the macrocytic form of deficiency will develop before the iron deficiency state. In either case, the true type of anemia can be readily established by laboratory studies, and the proper treatment can be instituted. The accompanying chart (Fig. 200) illustrates the development of the hypochromic iron deficiency state, followed somewhat later by a macrocytic type

of anemia in a patient who had total gastrectomy. This patient has now lived twelve and a half years since total gastrectomy for a malignant tumor, and could be followed only at quite irregular intervals because her home was at such a distance that she could not easily come to the clinic for examination and treatment. She did not, moreover, completely cooperate with her home physician. Since she has followed the full regimen under his care and has been examined at occasional intervals in the clinic, no further anemia has developed.

Farris, Ransom and Coller[3] have made significant observations which are of aid in correcting some of the difficulties following total gastrectomy. They stated that the stomach does not play an essential role in the digestion of fats and protein, but that the absorption of glucose is more rapid than normal. They concluded that a high protein, low carbohydrate diet is helpful in preventing abnormalities. However, it is evident after experience with a very large group of patients following total gastrectomy that these patients are able to maintain reasonable weight, to eat quite satisfactorily and to have a reasonably comfortable existence and feeling of well-being.

CONCLUSIONS

One hundred and thirty-nine cases of total gastrectomy are reported of which total gastrectomy was done for malignancy in 127 and for extensive gastric ulcer or gastric ulcer involving the cardia or esophagus in 12.

Since 1944 the mortality has been significantly reduced (9.4 per cent) and is now comparable to the mortality associated with partial gastrectomy for gastric neoplasm.

In view of the tendency of gastric malignancy not only to spread to adjacent lymph nodes but also to invade blood vessels and to show diffuse submucosal lymphatic spread in the gastric and duodenal wall well beyond the gross tumor, it is our belief that it is now time to suggest the employment of total gastrectomy in an increasing number of cases of cancer of the stomach, particularly in the earlier cases, if we are to improve the five-year survival rate in this field of malignant disease.

It is suggested that considerable discrimination in the selection of the cases for total gastrectomy is necessary and that the surgeon who undertakes a total gastrectomy must carefully weigh some of the following factors before proceeding with it: his technical skill and surgical experience, the quality and character of the anesthesia, the capacity of the patient to endure such a long and trying operation and the surgeon and his associates' ability to deal with the changes in conditions which will inevitably be associated with such extensive operations.

Patients following total gastrectomy are able to maintain a reasonable state of health, eat satisfactorily and carry on a comfortable existence. It will be necessary in many of these patients to maintain strict control of their diet and blood picture for long periods of time after operation.

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THE SMALL INTESTINE, COLON, SIGMOID AND RECTUM

RESECTION OF THE SMALL INTESTINE

KENNETH W. WARREN

Resection of the small intestine, particularly when performed in the absence of obstruction, is considerably less hazardous than resection of the colon. Factors which contribute to this relative safety in the segmental removal of the small bowel include (1) mobility, (2) rich collateral vascular supply, (3) well-developed submucosal and muscular coats, and (4) less infectious intestinal contents.

When obstruction is present, surgical manipulation of the small intestine may present a real challenge to surgical judgment and technical skill. Frequently, the choice of the proper time to operate and the election of an appropriate method of resection in instances of small bowel obstruction are requisite to a successful outcome.

GENERAL CONSIDERATIONS

The functional reserve of the small intestine is great and this factor permits of a generous sacrifice of the bowel in those pathologic states wherein wide excision is indicated, as in malignant disease and chronic nonspecific enteritis. It is important, in the latter condition, to search the entire intestine for "skip" areas of involvement and to resect well beyond the obvious limits of the disease.

Lesions of the small intestine are frequently obscure and their detection may require minute inspection of the entire structure, from the ligament of Treitz to the ileocecal valve.

PREOPERATIVE PREPARATION

The profound disturbances in fluid, electrolyte and nutritional balance in the presence of intestinal obstruction require vigorous restorative measures. Time spent in the restoration of normal blood volume and chemical values prior to surgery is often reflected in lowered mortality figures.

Intestinal intubation, in both the obstructed and nonobstructed bowel, is of inestimable value. In the presence of obstruction, the indwelling Miller-Abbott tube will effect some measure of decompression before surgery, it will afford safer manipulation of the bowel during the operation and will present a means of further decompression of the distended bowel by being advanced manually by the operator as constant suction is applied. In this manner one may obviate the more dangerous procedure of enterostomy decompression as a preliminary to resection. The Miller-Abbott tube will protect the suture line following the operation.

METHODS OF RESECTION

A wide variety of technics[1] is available for small intestinal resection and the choice of a procedure should be determined by a consideration of (1) the loca-

Originally published in Surgical Clinics of North America, 29 817–827 (June) 1949.

tion of the lesion (particularly those near the ligament of Treitz or the ileocecal valve), (2) the presence or absence of obstruction and (3) the familiarity of the operator with a particular technic. The vehemence of the argument in certain quarters regarding the superiority of the "closed" or aseptic over the "open" method, or vice versa, is disproportionate to the relative merits of either. The essential problem is to master a few procedures which, as a group, are applicable *to the entire gamut of situations which will* demand small bowel resection. In this mastery of a limited number of technics, I believe, it should be recognized that in certain situations a particular method is superior to another method which the operator might, under more usual circumstances, prefer to employ. It is, for instance, easier and safer to employ an end-to-end open anastomosis in resection of the small intestine when the lesion is near the ligament of Treitz or the ileocecal valve, provided no great disproportion between the caliber of the proximal and distal bowel exists. By the same token, it is impossible to approximate the greatly distended proximal segment of bowel to the deflated portion of distal intestine by end-to-end anastomosis. This disparity in relative size of the lumen of two portions of the bowel to be joined may also preclude the employment of *the clamp method of aseptic anastomosis.*

Resection of the small intestine by exteriorization is a procedure which is no longer widely employed, but is of some merit and it should be resorted to in certain desperate situations when the exigencies of the moment dictate a minimum of surgical manipulation.

It is noteworthy in this regard that Gross and Ware,[3] who have had a considerable experience with intestinal resection for irreducible intussusception in infants, prefer resection by exteriorization to primary anastomosis in this very hazardous situation. Although the present author is on record[2] as partial to the principle of immediate restoration of the continuity of the intestine in irreducible intussusception, one should not ignore the availability of the simpler method of resection by exteriorization.

Despite one's acquired preference for a certain method of small bowel resection it is reasonable to contend that a lateral anastomosis by the open method is, perhaps, the simplest and safest procedure to employ if one wishes to apply a single technic to the widest variety of lesions of the small intestine. This method avoids all manipulation of the mesenteric border during the fashioning of the stoma. All sutures are placed under direct vision which insures careful approximation and adequate hemostasis, with no possibility of an obstructing septum which is possible with the closed clamp technic. An adequate stoma is more definitely insured.

TECHNIC

Spinal anesthesia is preferable unless some compelling contraindication to its use is present.

The abdomen is generally entered through a vertical, muscle retracting or muscle splitting incision in the particular quadrant where the disease is anticipated. In the absence of an acute emergency, the entire abdominal cavity is carefully explored. The lesion is inspected and the limits of resection are determined. The peritoneum on each side of the mesentery is incised in a wedge-shaped fashion,

as indicated in Figure 201. The individual vessels are divided between small straight hemostats and are carefully ligated. The points of election for division of the bowel are cleared of all mesenteric fat. The decision is then made with respect to the type of anastomosis that is to be accomplished, and the details of the remainder of the procedure are pursued in accordance with the manner of restoration that has been selected.

End-to-end Open Anastomosis. Paired Ochsner clamps are applied to the two areas of intestine previously prepared, the bowel is divided with the live cautery and the segment containing the lesion is discarded. The proximal and

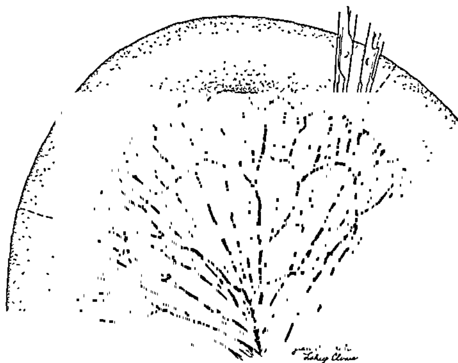


Fig. 201. The mesenteric vessels supplying the segment of bowel to be resected are divided between clamps after the peritoneal covering on each side of the mesentery has been incised.

distal segments to be united are held in close proximity and the posterior or mesenteric surfaces are approximated with interrupted sutures of fine silk (Fig. 202, *a*). The clamps are removed and the second posterior row of sutures, consisting of a continuous, interlocking strand of medium chromic catgut, is placed through all layers (Fig. 202, *b*). This suture is continued anteriorly, after the manner of Connell, as a through-and-through inverting suture (Fig. 202, *c*). The anterior portion of the anastomosis is completed by the application of a row of Lembert sutures of fine silk. The defect in the mesentery is closed by approximating the peritoneal edges on each side of the mesentery by continuous fine catgut or interrupted silk sutures (Fig. 202, *e*).

Lateral Open Anastomosis. The bowel is divided between paired clamps and the proximal and distal ends are closed with a continuous suture of chromic catgut (Fig. 203, *a*), and inverted with a row of Lembert sutures of fine silk. The two ends of the divided intestine are then overlapped for a distance of approximately 7.5 cm., and the apposing walls are united near the mesenteric borders

with a row of interrupted sutures of fine silk (Fig. 203, *b*). Parallel openings are made in each segment of bowel about 1 cm. from the previously placed line of sutures. The posterior margins of the stoma are approximated with a continuous interlocking suture of chromic catgut (Fig. 203, *c*), which suture is con-

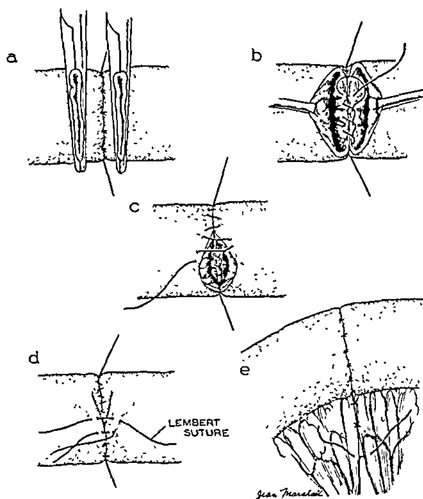


Fig. 202. End-to-end open anastomosis.

a, The proximal and distal segments of the divided intestine are apposed with a row of interrupted silk sutures.

b, The clamps have been removed and the anterior margins of the intestine have been retracted with Allis forceps. The posterior margins of the stoma are approximated with a continuous interlocking suture of chromic catgut.

c, The posterior suture is continued anteriorly as a Connell suture, inverting the anterior margins of the divided bowel.

d, Interrupted Lembert sutures are used to reinforce the anterior closure.

e, The mesenteric borders are united with interrupted sutures.

tinued anteriorly as a Connell suture, inverting the anterior margins of the stoma. The anterior closure is completed with an additional row of Lembert sutures of fine silk (Fig. 203, *d*). The overlapping mesentery is closed on each side with a continuous suture of fine catgut.

It is essential that the closed ends of the intestine do not project to any considerable degree beyond the margins of the stoma if mild obstructive symptoms are to be avoided.

An alternative method of open lateral anastomosis is that described by Hal-

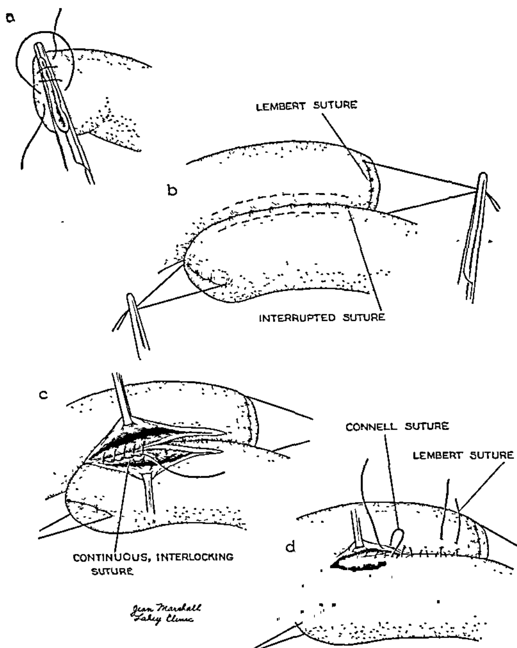


Fig. 203. Side-to-side open anastomosis.

a, Each end of the divided bowel is closed over the clamp with a simple inverting suture of chromic catgut, and reinforced by interrupted Lembert sutures of fine silk (*b*).

b, The proximal and distal segments are overlapped for a distance of 7.5 cm. and united near their mesenteric borders with a row of interrupted silk sutures.

c, Openings are made in the two segments of apposed bowel, parallel to and about 1 cm. distant from the row of previously placed sutures. The posterior margins of the stoma are united with a continuous, interlocking suture of chromic catgut.

d, The anterior closure is accomplished by continuing the posterior mucosal suture anteriorly after the manner of Connell, and reinforcing it with a row of interrupted Lembert sutures. The mesenteric defect (not shown in illustration) is closed by a row of interrupted sutures on each side of the overlapping mesenteric margins.

sted and modified by Finney. In this procedure the two segments of intestine are apposed with a row of interrupted sutures of fine silk, as in the method described above. The anchor suture at one angle of the prospective stoma is placed in the groove formed by the apposed surfaces of the intestine. A series of interrupted sutures of fine silk is now placed in the two segments of intestine in the following fashion. Beginning as a Lembert suture approximately 1.5 cm. from the row of previously placed sutures and continuing to the opposite segment of bowel as a lateral mattress suture equidistant from the original suture line, the stitch is completed as a Lembert suture on the original segment of bowel from whence the stitch began. A series of similar sutures is placed until one half of the length of the proposed stoma has been traversed. These sutures, which are left untied, are drawn out of the field and the other half of the row of sutures is placed in a similar fashion. Parallel openings are made opposite one another in the apposed segments of bowel, between the parallel rows of

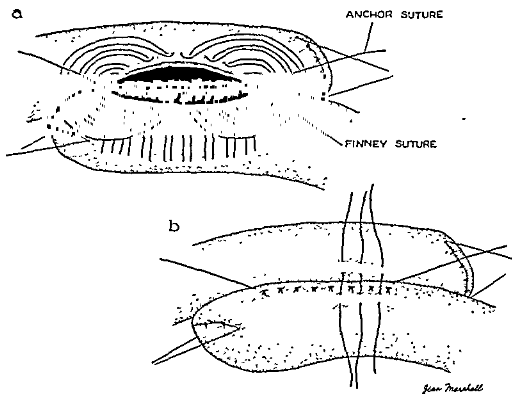


Fig. 204. Alternate method of side-to-side open anastomosis. The ends of the divided bowel are inverted and the proximal and distal segments are overlapped and united with a row of interrupted sutures of silk, as described and illustrated in Figure 203, *a* and *b*.

a, Before the parallel openings are made in the apposed segments of intestine the first row of anterior sutures is placed in the following fashion. Beginning as a Lembert suture on one segment of the apposed bowel, about 1.5 cm from the row of previously placed sutures and continuing to the opposite segment of bowel as a lateral mattress suture equidistant from the original suture line, the stitch is completed as a Lembert suture on the original segment of bowel from whence it began. These sutures, all of which are left untied, are drawn out of the field as indicated and parallel openings are made in each segment of the intestine. The posterior margins are approximated with a continuous interlocking suture of chromic catgut (*b*). The previously placed anterior row of sutures is now drawn taut in unison and tied individually. A row of Lembert sutures may be used to reinforce the anterior closure.

sutures, and the posterior margins of the stoma are approximated with a continuous interlocking suture of chromic catgut (Fig. 204, *a*). The previously placed anterior sutures are now drawn taut in unison, thereby inverting the

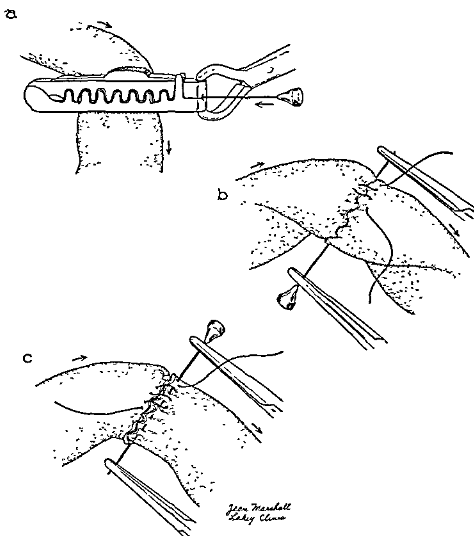


Fig. 205. End-to-end closed anastomosis employing Furniss (McClure) clamp.

a, The McClure modification of the Furniss clamp has been applied to the proximal and distal segments of bowel and the diseased portion has been removed. The needle is being inserted into the "eye" of the clamp in order to transfix and secure the cut margins of the intestine.

b, The clamp has been removed and the needle, which transfixes the serrated margins of the bowel, has been rotated through 180 degrees, thus bringing the posterior surfaces of the segments of intestine into the anterior plane. A continuous suture of fine chromic catgut, tied at its beginning point and locked at its termination, unites the posterior surfaces of the divided bowel.

c, The transfixion needle has been rotated back through 180 degrees to the original position. Another continuous suture of fine chromic catgut approximates the anterior margins of the intestine. The appropriate ends of the anterior and posterior sutures are tied together at each angle, after the transfixion needle has been withdrawn.

anterior margins of the stoma. These sutures are tied individually. A second anterior row of Lembert sutures of fine silk may be employed to reinforce the closure (Fig. 204, *b*). The rent in the mesentery is closed as in the previously described method of lateral anastomosis.

End-to-end Aseptic Method Employing Furniss Clamp. This method is most applicable when the proximal and distal segments of intestine are of equal caliber and of unrestricted mobility. The points of division are prepared as above. The Furniss clamp, or preferably the McClure modification of it, is applied to the proximal and distal segments of the bowel as they are held in close apposition to one another. A straight needle is inserted into the "eye" of the clamp, thereby transfixing the serrated portion of the bowel held in the clamp. Ochsner clamps are then applied to the proximal and distal ends of the segment of bowel that is to be removed and the intestine is divided with the live cautery (Fig. 205, *a*). The Furniss clamp is removed, leaving the ends of the bowel to be joined secured by the transfixion needle which, in turn, is rotated through 180 degrees. This maneuver brings the posterior walls of the prospective stoma into the anterior plane, where they are united by a continuous row

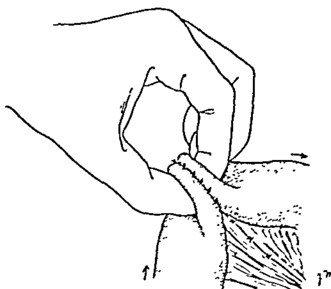


Fig 206. The agglutinated edges of the divided bowel are separated by invaginating the anterior wall of the intestine through the new stoma. The anastomosis is then reinforced by a row of interrupted Lembert sutures of fine silk around the entire circumference of the bowel and the mesenteric defect is closed with a series of similar sutures. One may prefer to employ a double row of Lembert silk sutures for this method of anastomosis.

of fine catgut (Fig. 205, *b*). The transfixion needle is now rotated back through 180 degrees to the initial position and the anterior walls of the apposed ends of the intestine are approximated with a continuous suture of fine catgut (Fig. 205, *c*). The transfixion needle is withdrawn and the agglutinated edges of the intestine are separated by gentle digital pressure, thus restoring the continuity of the lumen of the bowel. A row of interrupted Lembert sutures of fine silk, encircling the new stoma, completes the anastomosis (Fig. 206). The mesenteric defect is closed in the manner described above.

This technic, in general, is applicable to the utilization of a variety of specialized clamps designed for the accomplishment of aseptic anastomosis of the gastrointestinal tract. They may, in turn, be similarly employed for lateral anastomoses.

Mikulicz Resection of the Small Intestine. The mobilization and preparation of the points of division of the intestine for resection by the method of

exteriorization are identical with these maneuvers preliminary to [illegible] immediate anastomosis. When the Mikulicz method is dictated by [illegible] stance, the segment of bowel to be removed is divided between paired [illegible] the live cautery. The proximal and distal limbs are apposed in double [illegible] fashion with the proximal end projecting beyond the distal end by 2 cm. [illegible] a spur is formed by a double row of interrupted sutures of fine catgut, [illegible] amesenteric segments of the bowel. The abdominal wall is closed in layers [illegible] *the exteriorized intestine.* A dressing is applied, leaving the proximal [illegible] of intestine exposed in order that it may be decompressed as a final step [illegible] procedure. This decompression is accomplished by inserting a soft [illegible] catheter of appropriate size into the proximal loop below the peritoneal [illegible]. The catheter is anchored in position by a previously placed purse-string [illegible] of chromic catgut.

The spur, in ordinary circumstances, is crushed by serial clamps beginning about the seventh postoperative day. The restoration of intestinal *continuity* [illegible] accomplished surgically, approximately eight weeks after the *initial* [illegible]

This method of resection has a limited range of *application today,* [illegible] ignore its existence is to deny the occasional patient who is *desperately* [illegible] most reasonable chance of recovery.

POSTOPERATIVE CARE

Constant suction is maintained on the indwelling Miller-Abbott [illegible] flatus is passed freely. It should be borne in mind, in this regard [illegible] Abbott tube, with its suction tip beyond the pylorus, does *not* [illegible] press the stomach and that it is therefore wise, in some [illegible] separate gastric suction via a Levin tube *in addition to the* [illegible]

Parenteral fluids, including adequate amounts of glucose, [illegible] *preparations* and whole blood, *are administered* until adequate [illegible] is feasible.

Prophylactic or therapeutic doses of penicillin, according [illegible] tions, are systematically employed.

Graduated diet and ambulation are varied according [illegible]

SUMMARY

General considerations relative to resection of the [illegible] cussed.

Various technics of small intestinal resection are de[illegible]

[illegible] r- [illegible] nd [illegible] ges [illegible] on of the [illegible] nodes has [illegible] *ostomy and* [illegible] estine offers a [illegible] erated, infected [illegible] or further spread [illegible] ere 9 patients in [illegible] king

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THE MANAGEMENT OF CHRONIC REGIONAL ILEITIS

EVERETT D. KIEFER, SAMUEL F. MARSHALL AND M. P. BROLSMA

The objective of this study was a critical evaluation of our present management of chronic regional ileitis with special attention to the problems arising in the patient who develops a recurrence of ileitis after surgical treatment.

This study was based on experience with 33 patients treated medically and 126 surgically treated patients. Fourteen of the latter group are also included in the medically treated group.

MEDICAL TREATMENT

The indications for medical management were: (1) localized disease of short duration and without complications, such as obstruction, fistula or abscess, and (2) uncomplicated but widespread disease involving so much small intestine that extirpation of all of the affected portion would seriously impair absorption.

Medical treatment was nonspecific with an over-all objective of supporting the patient's resistance to the disease, thereby promoting an arrest of the activity of the inflammatory process. It has been observed that when this occurs there may follow a remission of symptoms with resumption of normal intestinal function even though chronic cicatricial changes may still exist in the small bowel.

The principles of nonspecific supportive management are (1) bodily rest, (2) adequate nutrition, (3) reduction of intestinal activity, (4) correction of secondary systemic effects such as anemia, dehydration and hypoproteinemia, and (5) the control of infection.

Antibiotics. Sulfonamide drugs and penicillin were used in some cases but their action appeared to be nonspecific with no demonstrable effect upon the primary inflammatory process in the intestine and mesentery. It is only fair to say, however, that neither penicillin nor streptomycin has been used in large dosages over a prolonged time in any of these cases. The usefulness of penicillin was chiefly in connection with the surgical treatment of cases complicated by abscesses and fistulas as a preparation for operation and as a safeguard against postoperative sepsis. Aureomycin and chloromycetin may prove to be more useful, but so far experience with these drugs is limited.

Vitamins. Adequate vitamin intake appeared to be essential, but there was no evidence that any vitamin has any specific therapeutic value.

In several cases vitamin D was given over a prolonged period in dosages of 200,000 units per day. No clinical improvement which could be definitely ascribed to the vitamin D was observed.

Prolonged Bed Rest. On the basis that chronic regional ileitis may, like tuberculosis, become arrested when conditions favor an increase in the natural resistance to the disease it has seemed rational to apply sanitarium treatment or

Originally published in Gastroenterology, 14 118–126 (Jan.) 1950.

its equivalent particularly in cases with ileitis after an attempt at surgical cure.

Six patients including one with extensive involvement have been kept in bed at home for from two to six months with definite clinical improvement in all. Four patients are now experiencing a complete remission of symptoms. Longer observation of a larger series of patients treated in this way is necessary before it can be determined whether a remission is a regular result of such a measure or the favorable results are permanent.

Clinical Results of Medical Management

A total of 33 cases of chronic regional ileitis was treated by means of medical management and has been followed for three years or longer. Of this group 24 were diagnosed as having localized ileitis. Five patients have been relieved and have remained well over a period of from five to eleven years. One other patient has some partial disability but was improved. Eighteen were unrelieved or had early exacerbation of symptoms and surgical treatment was advised.

There were 9 cases of widespread ileitis in which medical management was undertaken more from necessity than from choice because they were considered to have too extensive involvement for surgical resection. Four of these patients were subjected to exploratory laparotomy but were closed without resection.

A follow-up of this group showed that 4 had been in good health for from three to nine years. Two were much improved although they had some disability. Two patients continue to be invalids and 1 patient has died of the disease.

The experience with medical management in chronic regional ileitis leads to the conclusion that although a majority of cases are unsuccessfully controlled there are some cases in which the disease becomes arrested. If, in localized, uncomplicated ileitis of the terminal ileum, the roentgenogram shows no chronic granuloma a medical regimen should be tried.

Even in cases of widespread involvement if there is no obstruction or perforation the situation is not hopeless. The disease may become arrested and reasonably good health is possible in the presence of extensive x-ray changes in the small intestine.

SURGICAL TREATMENT

In the surgical treatment of chronic regional ileitis radical resection of the diseased intestine, along with its mesentery and adjacent lymph nodes has been preferred rather than exclusion operations such as entero-enterostomy and enterocolostomy.

It has been our belief that removal of all diseased loops of intestine offers a better prospect of control of the disease. Conceivably, any ulcerated, infected area of intestine left within the abdomen remains as a focus for further spread of the inflammatory process, fistulas and abscesses. There were 9 patients in the surgical group who had been previously treated by means of side-tracking operations. Persistent active inflammation was observed in all cases and frequently the excluded loop was found to be obstructed, dilated and markedly ulcerated.

In the surgical resection of the terminal ileum, removal of the cecum and

ascending colon was always included because of the frequent involvement of the ileocecal juncture, and sometimes the entire cecum appeared to be inflamed. This technic also permitted a more complete removal of involved mesenteric glands.

In order to minimize the possibility of direct extension of disease care was exercised to place the upper limit of the resection through normal intestine well above the involved area.

Incidence of Postoperative Recurrence

There were 118 patients who were subjected to either a resection of a segment of the small intestine or a removal of the terminal loops of ileum along with the right colon.

The postoperative mortality has been low. There were only 2 postoperative deaths, both due to pulmonary emboli. Another patient, aged 61, died within a week of leaving the hospital in apparently good condition. The cause of death was not ascertained. Three patients were not improved by operation because of complicating sepsis which progressed after the patients left the hospital resulting in death in from four to sixteen months after operation.

For follow-up study concerning the postoperative course, 112 patients were available. Two of these are reported dead of undetermined causes. Eight have been followed for less than two years, leaving 102 postresection cases with a follow-up record of over two years.

Recurrent ileitis has been diagnosed or suspected in 43 of these 102 cases. In these 43 cases the diagnosis was confirmed by laparotomy in 21. In 13 the clinical and roentgenologic evidence was so convincing that the diagnosis of recurrent disease seemed to be unequivocal. In the remaining 9 cases the diagnosis was "probable recurrent ileitis" since the evidence was either not entirely convincing or was incomplete.

These figures indicate that in a group of patients treated for regional ileitis by surgical resection and followed for a period of from two to ten years the recurrence rate was at least 34 per cent.

Since recurrences have been observed as long as six years after operation a recurrence rate cannot be finally calculated until all patients have been followed for at least six years. However, since most of the recurrences begin to cause symptoms within two years after operation and all of the cases reported here have been followed more than two years and nearly half for four years or longer the recurrence rate is not likely to show much increase by the time the most recently operated case has been followed for six years.

Factors Which May Influence the Postoperative Recurrence of Ileitis

The relationship of certain clinical and pathologic factors with the recurrence of ileitis has been explored by comparing the recurrent group of cases with the nonrecurrent group.

The surgeon's estimate of the extent of disease was practically always recorded in his note describing the operative procedure. Arbitrarily, an involvement of

less than 12 inches has been taken as indication of a localized disease. Involvement of 12 inches or more has been regarded as extensive disease.

In the nonrecurrent group involvement was less than 12 inches in 39 cases and more than 12 inches in 20.

In the recurrent group the disease was localized in 12 cases and extensive in 30. The extent was not recorded in one case.

It was also noted that in the recurrent cases 4 patients had multiple areas of involvement with skip areas of normal intestine in between the diseased portions. This condition did not exist in any of the nonrecurrent cases.

From these data it may be concluded that the extent of involvement of the small intestine is one factor which does affect the recurrence rate.

The incidence of preoperative complications was also noted and compared in the two groups. In 43 cases with recurrence 8 had external fistulas, one had an internal fistula, 2 had intra-abdominal abscesses and 5 had fistulas-in-ano. In 59 nonrecurrent cases 9 had external fistulas, 6 had internal fistulas, one had an abscess and 2 had fistulas-in-ano. Signs and symptoms of intermittent small intestinal obstruction were found in 9 of the recurrent cases and in 16 of the nonrecurrent group.

The figures disclose that there is practically no difference in the incidence of complications in the two groups although fistulas and abscesses were a little more frequent among the recurrent cases. The systemic effects of the disease before operation were classified as mild or severe based upon the weight loss, disability, anemia and fever. In the 43 recurrent cases the systemic symptoms were classified as severe in 28 cases. Of the 59 nonrecurrent cases 27 were classified as having severe systemic effects. The difference in the severity of symptoms was not striking.

A review of all reports of the gross and microscopic pathologic change of the resected specimens which were all examined in the pathology laboratory of the New England Deaconess Hospital revealed no essential difference between the recurrent and nonrecurrent groups.

Whether removal of the right colon influenced the recurrence rate could not be determined since only 13 patients had resection of a segment of small intestine without removal of the right colon. Seven of these were in the recurrent and 6 in the nonrecurrent group.

DIAGNOSIS OF RECURRENT ILEITIS

The diagnosis of recurrent regional ileitis after operation is based upon the same clinical, laboratory and x-ray features that characterize the primary occurrence of the disease. When diarrhea, abdominal pain and weight loss appear postoperatively, recurrent active ileitis must be suspected even though a considerable period of apparently normal health has transpired since the operation. In our experience this time interval may be as long as six years.

In a review of the symptoms of 43 patients with postoperative recurrent ileitis, diarrhea consisting of six or more watery, foamy stools per day was the most common single complaint in 33 cases. Pain was an outstanding symptom in 23 cases, making it second to diarrhea as an important complaint. Weight

loss was another important symptom in 19 cases. Persistent fever was noted in 8 cases. The fever was usually less than 101° F. and was not accompanied by chills. Some hypochromic anemia was observed in nearly all cases with recurrence while in 5 the anemia was marked.

Recurrent abdominal fistula, an abdominal mass, perianal abscess or fistula, peripheral edema and gross bleeding per rectum were less frequent clinical signs but each occurred twice in the series of 43 recurrent cases.

As a rule the immediate postoperative reaction was one of encouraging clinical improvement. There was a varying period of satisfactory relief following surgical treatment before indications of recurrent or persistent disease began to appear. In only 3 cases were there definite signs of active ileitis within six months following resection. A total of 17 patients developed symptoms heralding a recurrence within the first year after operation and 11 patients had recurrence in the second year so that more than half of the recurrent cases showed clinical manifestations within two years.

Further evidence of the striking time delay before recurrent or persistent disease makes itself manifest was supplied by 5 recurrent cases in the third year, 6 in the fourth year, and the fifth, sixth and seventh years each furnished one recurrence.

An estimate of the activity of the disease process may be made from an appraisal of the symptoms and from laboratory blood studies. In active ileitis there was usually a mild hypochromic anemia but sometimes the degree of anemia was marked. The white blood cell count was rarely elevated except in patients with fistulas or abscesses. The red cell sedimentation rate was more frequently elevated and is good evidence of either active inflammation or disturbed nutrition. Lowering of the albumin-globulin ratio was found to be an index of activity of recurrent ileitis but was most marked in association with impaired absorption and malnutrition.

Differential Diagnosis. In the diagnosis of symptoms which arose after operation it was necessary to differentiate recurrent ileitis from the effects of the removal of more or less extensive portions of the small intestine and the right colon.

Diarrhea alone did not necessarily indicate recurrent disease. In fact 40 per cent of postresection cases with no other evidence of recurrent ileitis had four or more watery stools per day. Only 20 per cent had normal formed stools.

Abdominal pain, which is indicative of intestinal irritation and therefore more suggestive of recurrent inflammation, was not complained of by any of the patients who did not have recurrence, apparently because their diarrhea was on the basis of inadequate fluid absorption.

Diarrhea due to postoperative intestinal hypermotility was not found to be accompanied by fever, leukocytosis or increased red cell sedimentation rate.

Characteristeric roentgenologic changes in the remaining small bowel were considered to be essential confirmatory evidence before a diagnosis of recurrent ileitis was made. In cases of recurrence it was usually the terminal ileum just proximal to the ileocolostomy that showed the most marked involvement. It was necessary to distinguish the characteristic x-ray signs of ileitis from a dif-

fuse atony of the small bowel causing puddling of the barium and some obliteration of normal mucosal markings. This latter state was found frequently in postoperative x-ray studies particularly in patients who had had considerable preoperative obstruction.

It was also necessary to differentiate cases of impaired absorption from recurrent ileitis although it is possible for the two conditions to coexist. This condition was most frequently observed after secondary operations for recurrent ileitis. Impaired absorption was found to cause many symptoms commonly associated with ileitis, such as diarrhea, weight loss, anemia, hypoproteinemia, edema and many signs of vitamin deficiency. If there was no complicating sepsis there was no fever or abdominal pain. The x-ray findings are those of a marked deficiency disease causing atony of the small and large intestine, puddling of barium and flattening of the mucosal pattern.

Confirmatory laboratory evidence consisted of anemia, in some cases macrocytic in type, low serum albumin, low albumin-globulin ratio and low serum calcium figures. This sprue-like syndrome was sometimes a cause of tetany.

In the differential diagnosis of cases of recurrent intestinal disease the possibility of an intercurrent ulcerative colitis must be kept in mind. The relationship between regional ileitis and chronic idiopathic ulcerative colitis was strikingly emphasized by 5 cases of chronic ulcerative colitis which developed after resection of the ileum for regional ileitis. Because of this poorly understood contingency, the colon was always examined by barium enema and by sigmoidoscope as part of the diagnostic study in all cases of suspected recurrent ileitis.

THE MANAGEMENT OF RECURRENT ILEITIS

Medical Management. The problem of what to do for the patient with recurrent ileitis after resection was a perplexing one. Since it was feared that further resection of diseased intestine might lead to permanent impairment of nutrition additional surgery was usually avoided as long as possible.

As in the medical management of primary regional ileitis the medical treatment of postoperative recurrent ileitis was far from satisfactory.

Of the 43 patients with recurrent ileitis 12 were operated on as soon as the diagnosis was established, leaving 31 who were given a trial of medical treatment. In 14 the disease appeared to be arrested and satisfactory relief of symptoms was the result. It was in this group that prolonged bed rest appeared to be of especial value. These patients had no complications and the roentgenologic studies indicated less severe and more localized involvement of the ileum. Seven cases in this group had been classified as "probable recurrent ileitis." The 17 remaining medically treated cases were classified as poor results. One patient had died of ileitis, 9 patients have had a second operation and the others are more or less invalids.

Therefore, the milder, less extensive recurrent ileitis, constituting approximately one-third of all recurrences, may be expected to respond satisfactorily to medical measures.

Surgical Treatment. The treatment of postoperative recurrent ileitis with

secondary surgical procedures is also fraught with hazards and disappointments. In 18 cases a secondary resection was done and in 3 cases an enterocolostomy was done.

Summarizing the clinical results in the 21 patients subjected to secondary surgical procedures there were 8 patients who have been returned to satisfactory health. Two patients developed recurrent ileitis after the second resection; one died and the other recovered on medical therapy. Two patients developed ulcerative colitis which required subsequent resection of the colon and rectum. One patient developed postoperatively an acute ulcerative colitis with perforation and peritonitis with fatal results. One case is too recent for clinical evaluation.

The 7 remaining patients constitute the most striking group with regard to the postoperative clinical results. These patients were apparently relieved of recurrent ileitis by the second operation but at the expense of impairment of the function of absorption. In 6 of these cases the nutritional disturbance was so severe that semi-invalidism or complete invalidism was the result.

When multiple operations are performed, the total length of small intestine resected or side-tracked may be considerable and sufficient to impair absorption to the point at which nutrition becomes decompensated.

There was considerable difficulty in estimating the length of intestine removed. Even with the abdomen opened an exact measurement of the amount of intestine to be resected was not usually practicable and after the specimen had been removed, shrinkage and shortening took place rapidly. However, the length of the intestine as measured by the pathologist after the surgical specimen had reached the pathology laboratory was taken as the most accurate recorded information.

In 5 of the cases in which malnutrition became a problem the resected specimens totaled 80 cm. or more. Two patients had more limited resections but also had enterocolostomies which excluded an indeterminate length of small bowel.

There were, however, several patients who were able to maintain their nutrition even though the length of resected small intestine was over 80 cm. and in one case totaled 158 cm.

Since there appears to be no definite critical figure limiting the amount of small intestine that can be removed it is probable that the functional integrity of the remaining intestine is an important factor. Reported cases of massive resection of the small intestine for acute conditions show that nutrition can be maintained with only 4 or 5 feet of small bowel but in such cases the remaining portion is presumably healthy.

Radiation Therapy. Under the direction of Dr. Hugh F. Hare, radiologist at the Lahey Clinic, x-ray irradiation of the abdomen was employed in the treatment of 7 patients. The method was to divide the abdomen into four quarters and expose each quarter to a dose of 100 r. A course consisted of from four to eight such treatments given at one-day intervals.

The series was obviously too small to form the basis of any conclusions. It was difficult to ascribe definite benefit to the treatment although some patients did improve after x-ray therapy. One medically treated patient with extensive involvement was not improved. Another similar case has shown improvement

only after prolonged and energetic medical treatment. Five patients with recurrence after operation were treated. Two were not benefited and were later reoperated on. A third patient has made a good recovery. In 2 cases of postoperative recurrence x-ray therapy was combined with a second surgical procedure. In one case the results were excellent and in the other malnutrition has become a serious problem.

CONCLUSIONS

The most evident conclusion which may be drawn from this study is that both the medical and the surgical measures now in use are inadequate and far from satisfactory.

A critical review of the clinical results in this disease suggests that medical management should be given a thorough trial in all cases of localized uncomplicated ileitis and in all cases with involvement too extensive to permit surgical resection.

In addition to the usual supportive measures medical therapy should include a prolonged period of sanitarium care or its equivalent.

Surgical resection is indicated for all cases complicated by obstruction, fistulas, abscesses and granulomatous masses and for those cases which prove to be intractable on a medical regimen.

The recurrence of the disease in one-third of the resected cases indicates that surgery alone is inadequate and that additional measures are necessary.

It is suggested that a prolonged postoperative period of medical management including the newer antibiotics and a rest cure of six months or longer might reduce the incidence of clinical recurrences.

Our experience with the treatment of postoperative recurrent ileitis suggests that when there is any doubt as to the diagnosis or if the recurrent symptoms are comparatively mild, medical management should be given a prolonged trial.

If medical treatment does not control or arrest the disease further surgical resection may be indicated. Surgery is also indicated in cases of recurrent obstruction, fistula or abscess formation and in cases in which the x-ray evidence indicates that the recurrent process is well localized.

In cases of widespread involvement and cases showing evidence of some impairment of absorption, surgery should be undertaken only as a last resort and with the understanding that serious nutritional disability may follow any attempt to cure the disease by further removal of diseased intestine.

Although no exact figure is available it seems probable that the total resected small intestine should not exceed 72 inches as estimated by the surgeon before removal. The condition of the remaining small bowel should be taken into consideration in planning the surgical attack.

The value of x-ray therapy over the abdomen cannot be fully estimated from this study. Further trial seems to be advisable before it is discarded.

TECHNIC OF ILEOSTOMY

BENTLEY P. COLCOCK

In our experience approximately 25 per cent of all patients with ulcerative colitis will require surgical intervention. It may be indicated to save the lives of those patients who fail to respond to medical management, to treat those patients who develop a complication of ulcerative colitis such as perforation, obstruction, infectious arthritis or carcinoma, or to help those patients who have become chronic invalids as a result of anemia, malnutrition or intractable diarrhea.

The operation which offers the greatest value in the treatment of ulcerative colitis is ileostomy usually followed by total colectomy. Up to July 1950 we had operated upon 308 patients with ulcerative colitis. An ileostomy had been carried out on 247 patients, total colectomy on 179 patients and 60 patients had had partial colectomy at that time.[3] These cases represent the most serious form of the disease. In all of these cases there was extensive ulceration of the colon and rectum, often associated with an incompetent anal sphincter.

Even in those patients in whom ileostomy alone leads to healing of the ulcerated bowel and the relief of most if not all of their clinical symptoms, the extensive fibrosis and contraction of the colon following ileostomy usually eliminate any possibility of that bowel resuming its normal function. Patients with infectious arthritis rarely are relieved completely until the diseased colon itself is removed. A patient with severe ulcerative colitis who has had the disease for seven to eight years or more runs an appreciable risk of developing carcinoma in his diseased colon.[2] For these reasons and because of the fact that many patients in whom intestinal continuity has been restored have required a second ileostomy owing to recurrence of the colitis, we have come to believe that if ileostomy is performed it must be considered a permanent one, in most instances.

Since the ileostomy is something which the patient must live with the rest of his life, everything which can be done to prevent prolapse or retraction, to prevent formation of fistulas and to promote satisfactory daily function of the ileostomy has a decided bearing on the future health and happiness of that patient. The modern ileostomy bag, with its air-tight and water-tight union with the skin, permits the restoration of these patients to full social and economic activity. Any point in the construction of the ileostomy which will facilitate the secure fixation of the ileostomy bag is most important to these patients.

With increasing experience with ulcerative colitis one can learn to recognize early those patients who will require an ileostomy. Consequently, one is rarely called upon today to operate upon a patient with ulcerative colitis who is *in extremis* or who is already moribund. Nevertheless, few of these patients can be considered good operative risks, and while we believe, for the reasons already

Originally published in Surgical Clinics of North America, 31 775–782 (June) 1951.

given, that it is most important that the ileostomy be carefully constructed, it is also important to employ a technic which is relatively simple so that it can be carried out with a minimum of trauma and shock to a seriously ill patient.

TECHNIC

A short right rectus incision is so placed that when the ileum is brought out through the rectus muscle at the lower angle of the wound it will be at the center of the convexity of the lower abdominal wall in the right lower quadrant. The ileostomy bag will fit most securely at this site and will be approximately 2 inches below and 1 inch to the right of the umbilicus (Fig. 207). If the ileos-

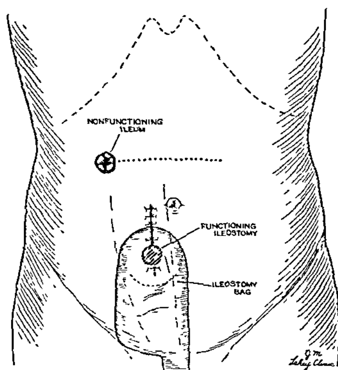


Fig. 207. The functioning ileostomy is placed at approximately the most convex portion of the right lower quadrant. If it is brought o... ough the original incision, as shown, this stab wou... that the symphysis, the anterior-superior spine a... the application of the bag.

tomy is too near the umbilicus, the anterosuperior spine or the symphysis pubis, it will be more difficult for the patient to fit the bag securely and leakage of ileal contents and gas may occur. If one prefers to bring the functioning ileostomy through a small stab wound rather than through the operative incision then it is the stab wound which must be carefully placed relative to these other structures.

The abdomen is not explored. To do so in the presence of severe ulcerative colitis is unwise since palpation of the edematous colon may lead to peritonitis.

It is important to have normal, healthy ileum for the ileostomy. Since the terminal few inches of ileum are involved in 20 per cent of these patients, the point in the ileum selected for the ileostomy should be at least 3 inches proximal to any possibly diseased small bowel, and will usually be at least 6 to 12 inches

proximal to the ileocecal valve. The mesentery of the ileum at this point is then divided perpendicularly to the bowel for a distance of 3 inches, and on the proximal side the mesentery is divided parallel to the bowel between the second and third vascular arcades. This permits the functioning loop to be brought out straight and eliminates any curvature of the ileostomy owing to its mesentery. Careful attention to the color of the bowel and pulsation of the terminal vessels will insure an adequate blood supply to the segments being exteriorized.

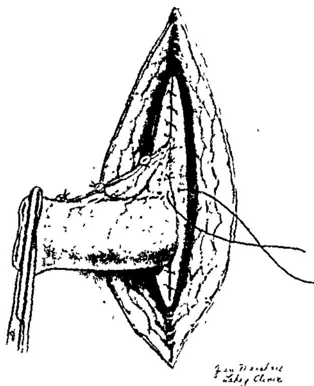


FIG. 208 Prolapse and retraction are avoided by careful fixation of the peritoneum of the ileomesentery to the parietal peritoneum of the abdominal wall and a similar row of sutures is placed on the opposite side of the mesentery, uniting it to the peritoneum of the abdominal wall. The ileostomy should project without tension at least 2 inches above the surface of the skin. The incision is closed in such a manner that it will not constrict the ileum.

A stab wound is then made in the abdominal wall above and to the right of the rectus incision. This is placed so that it can be incorporated in the supraumbilical transverse incision used for the subsequent colectomy. A curved Ochsner clamp is introduced through this stab wound, the ileum divided between clamps at the point selected and the distal nonfunctioning loop carefully withdrawn through the upper incision. We have never thought it wise to close this distal segment of ileum and drop it back into the abdominal cavity. If, as the result of healing and contraction, stenosis occurs at some point in the diseased colon, a closed loop would be produced as a result of closure of the distal ileum. Although Dennis[4] has pointed out that when loop "blows out" it does not blow out at the suture line, we would pref isk a tear at any point along

the diseased ulcerated intestine. Any possible herniation of the small bowel between the two loops of exteriorized ileum is prevented by approximation of the divided mesentery to the peritoneum of the anterior abdominal wall.

An ileostomy in the presence of ulcerative colitis is notorious for its tendency to prolapse or retract. Consequently, careful fixation of the functioning loop is a most important part of the operative procedure. At the clinic we prefer not to place sutures in the bowel wall itself. Dennis believed that fistulas which have resulted from the suture of the ileum to the abdominal wall are the result of

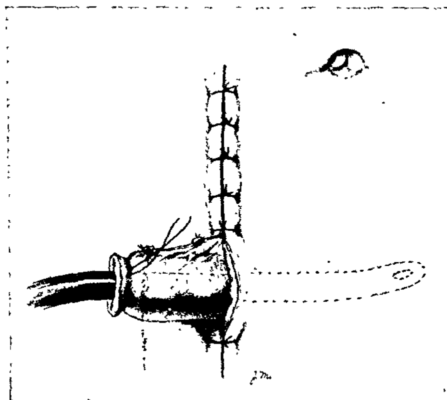


Fig. 209. After the incision has been closed and dressing applied, a large catheter is inserted into the ileum and through the abdominal wall. The catheter will keep the wound dry for a period of four to five days. It is removed at that time because thickening of the ileal content interferes with its proper function after this period.

using too heavy suture material or from penetration of the mucosal layer by the suture. Any patient with severe ulcerative colitis has an increased tendency to formation of fistulas, and with careful fixation of the mesentery it is unnecessary to place sutures in the wall of the bowel. A fistula is a serious complication. It markedly interferes with proper fixation of the ileostomy bag, and usually makes revision of the ileostomy inevitable. The peritoneum of the cut edge of ileal mesentery is sutured to the peritoneum of the abdominal wall for 1½ to 2 inches on each side, carrying the fixation to the mesenteric border of the bowel (Fig. 208). In actual practice it results in almost complete closure of the peritoneal layer of the operative incision. Care must be taken not to injure the mesenteric vessels which would lead to the formation of a hematoma in the mesentery and possibly impair the blood supply to the terminal ileum. The mesentery is fixed at a point which will permit the ileum to be exteriorized without tension for a

distance of 1½ to 2 inches above the level of the skin. After the usual shrinkage has occurred and the mucosa has grown down to unite with the skin, this will result in a soft, pliable ileostomy standing ¾ to 1 inch above the level of the skin. This will project well into the ileostomy bag when the bag is applied. The application of a skin graft[5] to the ileostomy does not appear to us to be advantageous since it creates a semirigid projection an inch or more from the anterior abdominal wall. The modern ileostomy bag is purposely made flat in order that it will be as inconspicuous and as comfortable as possible, and an ileostomy which empties directly into the bag well away from the skin is all that is necessary or desirable. If a skin graft is applied to the ileostomy it must be carefully performed, for constriction of the ileostomy and fistula formation have occurred as the result of contracture of the graft.

The incision is closed in layers using absorbable catgut sutures, being careful not to constrict the ileostomy at the peritoneum, muscle, fascia or skin level.

The surrounding skin is protected immediately by the application of compound tincture of benzoin, dressings are applied and with towel drapes about the ileostomy a soft catheter is inserted for decompression (Fig. 209), and held in place by a purse-string suture. This catheter will decompress the small bowel most effectively if it is passed through the abdominal wall to the intraperitoneal portion of the terminal ileum. No harm has resulted from this procedure provided the catheter is not thrust hard up against the wall of the bowel and irrigation of the ileum demonstrates that the opening in the tube is free of mucosa. This tube is connected to a bottle at the side of the bed and keeps the wound and surrounding skin dry for the next four to five days. By that time the ileal content contains semisolid material and it is best to remove the tube, protecting the skin by a layer of gauze and a sheet of rubber dam, and bringing the ileostomy out through a hole in the center.[1] The original dressing which adheres to the ileum and to the benzoin coated skin is helpful in securing early fixation of the ileostomy; it is not disturbed until the fourth postoperative day. From that time on, compound tincture of benzoin is applied with each change of dressing, and has proved to be the most effective way of protecting the surrounding skin until the ileostomy bag is applied. Skin irritation is much easier to prevent than to cure. If it does occur in spite of these measures, one may have to resort to aluminum powder, kaolin, fuller's earth, 5 per cent aqueous solution of tannic acid, face down position on a Bradford frame or some such device as the Ballinger cup to secure sufficient healing of the skin to permit fixation of the ileostomy bag. Once the permanent ileostomy bag can be used the problem of skin irritation is eliminated.

The Koenig-Rutzen bag was the first of the modern ileostomy bags and it still remains the bag of choice for some patients. Only rubber seems to adhere satisfactorily to the skin of these patients. Since the bags are all custom made and are consequently somewhat expensive, we have delayed fitting the patients with Rutzen bags until the ileostomy has shrunk to its permanent size, about six to eight weeks following the establishment of the ileostomy. During this time our patients have worn a large-mouthed type of bag (Travellor). Although convenient to use, this bag does not adhere to the skin and a certain degree of skin irritation and leakage occurs. Recently we have fitted our patients much

earlier, using a plastic type of ring with a bag on the same principle as the Koenig-Rutzen bag. This appliance (Torbot) is less expensive, which is particularly important for those patients whose ileal content results in relatively rapid deterioration of the rubber in the Koenig-Rutzen bag. It also permits revision of the size of the ileostomy opening in the plastic ring when the ileostomy shrinks. Present indications are that another more recently developed bag (Perma-type) may be worn for several days between changes, the bag maintaining a water-tight, odorless union with the skin throughout this time. The use of this bag must be delayed until shrinkage of the ileostomy has occurred.

During the early postoperative period vomiting or the loss of unusually large quantities of fluid, chloride, potassium and other electrolytes from the ileostomy may quickly result in marked change in the fluid and electrolyte balance of these patients. This fluid and electrolyte loss, if not recognized and corrected, will result in a sudden and serious deterioration in the clinical condition of the patient. We have learned to suspect the presence of a potassium deficiency whenever there is difficulty in maintaining a normal chloride level.

Mild obstructive symptoms during the early postoperative period may require gentle dilatation of the ileostomy with the finger. If this is not sufficient to correct the obstruction the ileum is irrigated with a catheter until function is restored. Occasionally decompression from above with the Miller-Abbott tube will be required for a brief period.

LOOP ILEOSTOMY

If an ileostomy is required for a patient so seriously ill that even the technic described seems too formidable, the surgeon should resort to the simple loop type of ileostomy. A loop of healthy terminal ileum is brought through the same small right rectus incision, the bowel divided and the mesentery fixed as already described. Although this method eliminates the need for a second incision (stab wound) and thus shortens the procedure to a certain extent, it has the disadvantage in that the distal loop of ileum must be dealt with at the time of the subsequent colectomy.

ILEOSTOMY AND RIGHT COLECTOMY

Occasionally the reverse is true and right colectomy may be carried out at the same time that the ileostomy is performed, thus making it possible to complete the surgical treatment of these patients in two stages instead of three. For example, we recently operated upon a university student in whom an ileostomy and right colectomy were carried out in one stage. Although he had had extensive ulcerative colitis for many years, he was not toxic, malnourished or anemic. The immediate indication for surgical intervention was an incompetent anal sphincter which had made it impossible for him to continue in school. It is our conviction, however, that this combined procedure of ileostomy and right coletomy should be carried out only in those patients who are in the chronic, cicatricial stage of the disease if the present low mortality rate for ileostomy is to be maintained.

From January 1947 to July 1950, 141 patients were operated on for ulcerative colitis. In the group of 74 patients who had ileostomy alone there were 2

deaths, a mortality of 2.7 per cent. In the small group of 26 patients who had an ileostomy combined with right colectomy there were 3 deaths or a mortality of 11.5 per cent. The operative mortality following ileostomy and colectomy was 2.3 per cent.

When ileostomy is combined with colectomy the right rectus incision is made somewhat longer, the terminal ileum, right colon and proximal transverse colon are resected and the distal segment of colon is exteriorized through a stab wound to the left of the umbilicus where it can be incorporated in the left rectus incision used for the subsequent left colectomy and abdominoperineal resection. The operative field is then reperitonealized and the space between the ileum and lateral abdominal wall closed to prevent possible rotation and torsion of the ileostomy. The ileostomy is fixed in the usual manner.

CONCLUSIONS

The problems associated with an ileostomy carried out for ulcerative colitis are gradually being solved. A well constructed ileostomy plus the modern ileostomy bags permits the restoration of these patients to normal social and economic activity. As these facts become more fully appreciated by the patient and by the physician, fewer patients will die of ulcerative colitis and many more will be rescued from a life of chronic invalidism.

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INDICATIONS FOR SURGICAL INTERVENTION IN ULCERATIVE COLITIS

FRANK H. LAHEY

Up to fairly recent years nonspecific ulcerative colitis has been a serious disease about which we have known very little concerning the cause of its appearance, and nothing concerning specific factors which bring on the disease. It is a disease which we have been forced to manage almost entirely in a symptomatic way. Its nonsurgical treatment has been extremely vague, directed largely toward the avoidance of things which have been known to promote acute episodes of the disease, such as emotional upsets, infections, excessive physical efforts and allergic reactions. Our efforts in the fairly recent past in treating patients with this disease have been based upon the assumption that once they have it, little or nothing can be done to rid them completely of it. Such measures as have been employed have been directed almost entirely toward the complications which occur in the course of the disease.

Prior to the attainment of the gratifying surgical refinements developed in fairly recent years in the making of an ileostomy, in the management of it with adherent bags after operation and in removing such infected colons and rectums, we had accepted the position that almost anything in the way of delay, risks and complications was acceptable, based upon the fact that ileostomy in its making and management was such an undesirable misfortune that all of the hazards previously mentioned and shown in mortality figures (Table 1) were worth accepting to avoid it entirely or to put it off for the longest possible period of time.

We have had the opportunity to deal with 770 patients with ulcerative colitis in the period when the above state of affairs was true, and through the recent years when this unhappy plight has changed quite completely and acceptably.

The unfortunate and frequently fatal complications occurring in patients with advanced stages of ulcerative colitis during the first era referred to were the result of the explainable delay in the performance of ileostomy and our inability to control the progress of the disease other than by this surgical measure (ileostomy). Internists understandably and properly delayed sending patients with ulcerative colitis to surgeons for ileostomy until such was the serious state of the patient from advanced (toxic) stages of the disease that the internists, family physicians, all members of the family and the surgical consultants were unanimous in their opinion that ileostomy, however repulsive it might be, was the sole available measure by which the patient's life could possibly be saved. It was evident then and is more so now that this approach to the problem made the surgical treatment of these cases by ileostomy and multiple stage colectomy

Originally published in Annals of Surgery, 133:726–740 (May) 1951. J. B. Lippincott Co., publishers.

unavoidably far from satisfactory. Many of these patients came or were sent for surgical management in such an acute stage of intoxication that the performance of the simplest type of ileostomy was followed by a fatality in many instances (18.6 per cent). Many of the patients were in advanced stages of hepatitis with multiple fistulas—rectal, vaginal and abdominal—and many were in such advanced stages of malnutrition (Fig. 210) that even the most minor surgical procedures were undertaken only with an almost prohibitive mortality rate (Table 1).

Table 1. Data on Operations for Ulcerative Colitis

		NUMBER
Total cases treated surgically		308
Ileostomy cases		247
Partial colectomy		60
Total colectomy		179
To 1947		
	NUMBER	MORTALITY, PER CENT
Total cases treated surgically	166	22.3
Ileostomy cases	142	18.6
Procedure mortality for the 166 cases	...	11.8
From January 1947 to July 1950		
	NUMBER	MORTALITY, PER CENT
Total cases treated surgically	142	4.2
Ileostomy cases	102	2 0
Ileostomy with right colectomy—cases	26	11.5
Procedure mortality for the 142 cases	...	2.3

Not only were internists, gastro-enterologists and family physicians reluctant to submit these patients to ileostomy because of the inability at that time to manage the resultant ileostomy with its liquid discharges, bad odor and skin irritations, but such were the complications of the ileostomy itself that even the surgeon employing it approached its performance with justifiable apprehensions. The effect of the discharge of ileal contents upon the surrounding skin, with no type of bag which could be cemented to the skin* to protect it then available, left the patient in constant discomfort from the skin erosions, ulcerations, burning and smarting, and the security of the ileostomy itself was jeopardized by the digestion of the abdominal wall about the ileostomy with its contents constantly bathing the surrounding skin. In this period few surgeons who had any considerable experience with this type of ileostomy failed to see such an ileostomy digested away from the abdominal wall, and retract into the abdomen, bringing about a fatal peritonitis.

*There are now obtainable a number of ileostomy bags which are cemented to the skin and we do not wish to promote any [illegible] however, not to remind all patients requiring [illegible] how much they and we are indebte[illegible] was a pioneer in developing the idea of the fitted ileostomy bag with a collar cemented to the skin.

Prolapse of the ileostomy was not an uncommon complication in everyone's hands, and not infrequently secondary operations were required to reduce large segments of ileum which had prolapsed through the eroded and inflamed abdominal wall.

The accuracy of the above statements is affirmed by the fact that of the first 145 ileostomies done in this clinic there were three understandable suicides, understandable because of the suffering from skin digestion, because of the exclusion of these three young people from acceptable lives and because of depression about a future unassociated with any possible satisfaction or happiness. As evidence that conditions in relation to ileostomy have changed the recent mortality figures are submitted (from January, 1947, to July, 1950, the mortality for 102 ileostomies was 2.0 per cent. Table 1) and the fact that not only have there been no suicides in the patients with ileostomies in this latter group but an ileostomy club is now in the process of formation by one of our most enthusiastic patients. Its purposes are the exchanging of views as to the patients' complete satisfaction, their method of now managing their lives with an ileostomy and the aiding and encouraging of others who may require an ileostomy or who have recently had one.

Table 2. ACTH in Ulcerative Colitis

		NUMBER
Total number of patients		28
No apparent benefit		7
Immediate benefit—left hospital improved		21
Still in remission (follow-up less than 4 months in nearly all)	13	
Recurrence	8	

To anyone who has not lived over the years of management of cases of ulcerative colitis in its various active and quiescent stages, all of this semi-reminiscent background may seem irrelevant and unnecessary. It is extremely important, however, to record these facts as we discuss the indications for surgical intervention in ulcerative colitis today because the changes in the management of this disease, especially from a surgical point of view but also in no inconsiderable way from a medical point of view, have entirely overcome most of the factors which brought about these depressing states. It is now possible, at least in an encouraging number of patients treated with ACTH, to interrupt acutely progressing stages of this disease and to bring about a remission during which ileostomy and colectomy can be accomplished (Table 2) if they are indicated rather than having to undertake the first step in the surgical treatment (ileostomy) of complications of this disease during a period when its performance formerly resulted in such a high mortality. The mortality of ileostomy itself merely as a technical procedure should be practically zero, leaving the operative mortality limited almost solely to the stage of the disease in which it is done.

Not only are we better able to manage these patients from the point of view of medical care but we have now refined the performance of ileostomy and its management postoperatively so that not some but all of the above-mentioned unhappy complications such as skin erosion, prolapse and retraction of the

ileostomy no longer occur. In comparing the surgical management of the complications of ulcerative colitis before and after 1947 and since that time, perhaps the most convincing evidence of this change is our own mortality rate for ileostomy. Prior to 1947 we have many times reported that the mortality for ileostomy was 18.6 per cent. Since that period (from January, 1947, to July, 1950) it has been 2.0 per cent. There were very few patients who had had ileostomies prior to 1947 upon whom we could call to attest to other patients who

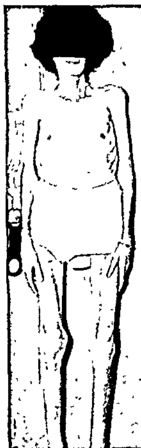


Fig. 210



Fig. 211.

Fig. 210. This photograph of a patient with severe ulcerative colitis illustrates well the degree of emaciation which can occur and also explains the hazards of surgical procedures in patients in this advanced state of the disease.

Fig. 211. This roentgenogram shows fuzziness of the haustrations in the earlier stages of ulcerative colitis, as indicated particularly at the points where the arrows are placed.

were contemplating this operation as to the comfort and the satisfaction with which they could conduct their lives with the present method of making and handling an ileostomy. Now literally all patients with ileostomy are not only willing but anxious to demonstrate to prospective patients for ileostomy how satisfactorily they can conduct their lives and activities without embarrassment, discomfort or limitations, with a properly made ileostomy and a properly fitted ileostomy bag cemented to their skin.

In its early stages ulcerative colitis is largely a mucosal disease, and in about 80 per cent of the cases the rectum is involved and its characteristic appearance may be demonstrated proctoscopically. Ulcerative colitis may be segmental or it may involve all segments of the colon. In the intermediate stage of the disease

haustrations may still be retained, but fuzziness, as illustrated in Figure 211, about the haustrations may be present. At this stage the process may be acute, subacute or in remission. In the late stage of the disease the colon in its entirety or in segments, as illustrated in Figure 212, may be completely rigid and of the lead-pipe variety. In all of these stages recurrent acute episodes and periods of remission occur, and in the late stage of the disease, surprisingly enough, occa-



Fig. 212. This illustration demonstrates the typical lead-pipe colon, not in an [illegible] stage of contraction, but with the haustrations absent.

sional patients, even those with a completely lead-pipe colon, [illegible] in complete remission over long periods of time without complications.

NONOPERATIVE MANAGEMENT

It is not the purpose of this paper to discuss the nonoperat[illegible] of ulcerative colitis, but so that no one will think that all ca[illegible] colitis require surgical intervention it is of value to state that [illegible] of ulcerative colitis under treatment in this clinic, 308, or [illegible] have been handled by surgical measures.

ACUTE EXACERBATION OF THE DISEASE

In the indications for surgical intervention in patients wi[illegible] must come first that of an acute exacerbation of the disease, [illegible] colitis [illegible] in the temperature chart (Fig 213) of a patient in whom a[illegible] brought about by ACTH. It is in this stage of the disease [illegible] ulcerative colitis largely rests. It is in this stage of the dise[illegible] between the surgeon and the internist is so necessary. The [illegible]

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will for the most part determine the mortality of ulcerative colitis will be based upon how long a patient, during an acute phase of ulcerative colitis, as shown in Figure 213, can safely be permitted to continue under a trial of nonsurgical management. It is in this stage of the disease that unwise persistence with nonsurgical measures on the part of the medical adviser, with his understandable desire to avoid an ileostomy, may commit this patient to advancement of the disease into such a stage that the ileostomy, when done, is unjustifiably hazardous. It is here that the judgment and the balancing warning of the surgical consultant avoid the undesirable delay resulting in the complications of this disease which bring about its avoidable mortality.

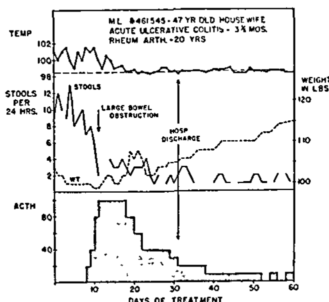


Fig. 213. This figure serves two purposes: (1) to show the acute phase of ulcerative colitis with high temperature and as many as 14 stools in twenty-four hours, and (2) to demonstrate graphically the prompt and successful remission in the acute process, brought about by the employment of ACTH. Note in the blocked section on the lower part of the chart the dosage and time periods of administration of ACTH.

As stated above, and as shown in the chart (Fig. 213) of a patient whose ulcerative colitis was converted into a remission stage by ACTH, it is possible that with this agent we now have a valuable method of avoiding the immediate necessity of performing ileostomies on patients in acute and toxic stages of the disease. We have now employed ACTH in 28 patients with ulcerative colitis and have succeeded in bringing about remissions in 21 cases and failed to do so in seven cases (Table 2). A much larger experience over a much longer period of time will be necessary before any dependable statements can be made regarding the success of ACTH in the treatment of ulcerative colitis. What its long range effect will be upon patients in the early stages of this disease, still mucosal in location and with complete retention of haustrations, is as yet unknown and will take time to determine. It seems unlikely that those patients in the late stages of the disease, with rigid colons, will obtain any more benefits from ACTH than will those in an as yet unproved percentage of cases in whom there is brought about remissions of acute phases of the disease.

It also is probably unnecessary to remind readers that after the administration

of ACTH, a period of four days must elapse to eliminate this substance before operation is undertaken, because it so interferes with wound healing.

There will undoubtedly be patients resistant to ACTH who will still require emergency ileostomies during the period of high temperature, multiple daily bowel movements and the discharge of large amounts of liquid stools mixed with blood and pus.* Despite the fact that the warning seems unnecessary, I would like again to call attention to what everyone knows who has dealt with this disease surgically: that is, in the acute phases of this disease the simplest type of ileostomy should be done. This is the simple loop ileostomy of a temporary nature but of such a type that it requires the least exposure of the peritoneal cavity and handling of the bowel. Attempts to do divided ileostomy with one segment, the proximal, in the right lower quadrant and the other implanted elsewhere in the abdomen as a first stage of a later colectomy will result in an avoidable high fatality rate in this stage of the disease.

HEMORRHAGE

In any disease of the colon of such ulcerating character as is nonspecific ulcerative colitis, hemorrhage is bound to be a not infrequent complication of



Fig. 214. This specimen represents the entire colon and rectum in a patient with massive hemorrhage uncontrolled by ileostomy, uncontrolled by the injection of plasma into the colon, and of such seriousness that the patient required 23 transfusions before total colectomy and abdominosacral removal of the colon were done in one stage as an emergency.

the disease, due (1) to the deep and multiple ulcerative processes in the colon and (2) to the fact that such colons are at times incapable of absorbing enough vitamin K to provide the essential elements for the synthesis of prothrombin in the liver. Living, as we do, in the midst of an immediately surrounding population of two million people, and being known as interested in this disease, it is inevitable that the problem of hemorrhage as a complication in ulcerative colitis not infrequently arises here. Few cases of ulcerative colitis reach the acute phase

* Ileostomy has already been necessary in six patients under treatment with ACTH.

of the disease—that is, with the high temperatures, multiple discharges of liquid character mixed with blood and pus—without the discharge of a not inconsiderable amount of blood. In an occasional case there will occur moderate discharges of pure blood in which, with the control of the disease either by nonoperative or operative measures (ileostomy), bleeding will promptly cease. Cases occur constantly, however, of serious massive and uncontrollable bleeding (Fig. 214) in which control of the bleeding by all measures is not possible, even with ileostomy, and an emergency colectomy, partial or complete, becomes imperative if the patient's life is to be saved. It has occasionally been necessary to do immediate removal of a part or the entire colon and rectum by abdominosacral resection in one stage in order to save such patients from complete exsanguination and death.

I know of nothing less encouraging to successful medical control in a patient with ulcerative colitis than the complication of massive bleeding. When it occurs, ileostomy should be done without delay, not only to put the colon at rest, with the hope that following this procedure bleeding will cease, but to establish the ileostomy and divert the fecal stream. If a colectomy, total or incomplete, then becomes urgently necessary because of failure to control the bleeding from the colon, it can be undertaken with the ileostomy already established and the fecal stream sidetracked.* If the ileostomy is done immediately, this step of the procedure will not be an additional burden to the patient who, after serious exsanguination, must go through an operation of no small magnitude, that is, the removal of part or all of the colon and rectum in one stage. Fortunately, most of our patients with massive hemorrhage in this disease have been in the young age group.

Not unlike the problems of when to operate upon a patient with a bleeding duodenal ulcer or how long one may delay the ileostomy in the acute exacerbations of ulcerative colitis, the fatalities from massive hemorrhage in patients with ulcerative colitis will in a large measure depend upon the surgeon and physician's co-operative judgment of when the possibilities of nonsurgical control of bleeding from the colon have been exhausted and aggressive surgical measures must be instituted. Today the nonsurgical measures for the control of bleeding from an ulcerated colon are limited in number and quite indefinite in character. We have as yet not had the opportunity to determine whether or not ACTH in such a complication will bring about cessation of bleeding, but other than this measure nonsurgical resources are limited to elevating the prothrombin time to normal and introducing plasma into the bleeding colon.

Since we have had a number of cases in which ileostomy, by means of which the colon may be put at rest, has not terminated the bleeding, and colectomy, partial or complete, has been necessary because of continuing massive hemorrhage, we have doubts that ACTH will provide the desired measure to stop bleeding. When such a serious complication resulting from deep ulcerations does occur, the process has by this time probably become an irreversible one.

* The combination of ileostomy with colon resection, as shown in Table I, in which 26 patients had ileostomy and partial resection of the colon combined in one operation, elevated the mortality rate unduly. Such procedures should be combined only in good risk patients by surgeons experienced with this disease, and even then with extreme caution.



Fig 215. This roentgenogram is shown to demonstrate complete obliteration of the splenic flexure and marked shortening of the entire colon as a result of the infiltration and cicatrization of the colon.



Fig. 216. This is another example of a colon in which the flexures have been almost completely obliterated. It again demonstrates the added ease with which colectomy can be done on patients with ulcerative colitis when late cicatrization has obliterated the flexures and shortened the colon.

One of the problems in patients with massive hemorrhage in ulcerative colitis is that of localization of the bleeding and selection of the colon to be removed. When the bleeding is bright in character it is probable that the active process is between the splenic flexure and the anus, but such is the ability of the contracted colon to obliterate its flexures and shorten the colon, as shown in Figures 215 and 216, that this is a less dependable feature than in the colon of normal length and with normal flexures. The decision as to which segment to remove first can be a difficult one. Since in many of the patients with advanced ulcerative colitis there will be a contracted colon and obliterated flexures, an abdominosacral removal of the rectum, together with the colon up to the transverse colon, will offer the best chance of removing the segment of colon which is responsible for the bleeding. After this section of colon has been removed it can be opened and if the bleeding area can be demonstrated in the specimen to extend beyond the removed area, the remaining portion of the colon can readily be taken out. Actually, in cases of ulcerative colitis with contracted flexures, hepatic, splenic and sigmoid, total colectomy is technically a less difficult operation than is partial colectomy in cases in which the flexures are intact.

PERFORATIONS (ACUTE AND CHRONIC)

Acute perforation in patients with ulcerative colitis has not been a common complication in our experience with this disease. This is probably due to the fact that the process is a diffuse infiltrating one and not a localized one, that it is slowly progressive, giving the infiltrated colon an opportunity to cicatrize ahead of the process, and also due to the fact that in the beginning ulcerative colitis is a mucosal disease, followed later in the advanced stages of the disease by gradual thickening and cicatrization of the muscular coats of the bowel wall. Acute perforation of ulcerative colitis is to be dealt with the same as acute perforation elsewhere, except that the bowel wall in ulcerative colitis is friable, holds stitches badly, does not invert and contains organisms of a highly virulent character. In the earlier acute phases of ulcerative colitis when the bowel wall is still flexible and has not as yet become cicatrized, there is a graver danger of perforation than in the later stages of the lead-pipe colon. It is in this stage, when haustrations are still present (Fig. 217), that acute ulcerating episodes can bring about perforation and it is in this stage that infolding of the perforated area will be more successful. All closures of perforations for ulcerative colitis should be combined with an ileostomy.

The most common type of perforation with which we have had to deal is the chronic perforation so frequently associated with obstruction and with a walled-off abscess. This type of lesion is best dealt with by preliminary ileostomy followed by local drainage of the walled-off abscess and later resection of the colon.

OBSTRU

Intestinal obstruction in ulcerative colit ith surprising infrequency. This, again, I is due to the fact ocess does not produce its effect locally y along the tube 'n the beginning involving the mucosa ltrating the mus This is wel rated by



Fig. 217. In this illustration haustrations are lost in the descending colon but retained in the ascending and proximal transverse colon. Note the retention of the splenic, sigmoid and hepatic flexures because cicatrization and contraction have as yet not taken place here. This patient had such massive hemorrhage from ulceration of the descending colon that resection of this segment was necessary in the middle of the night.



Fig. 218. This photograph of a removed specimen of ulcerative colitis shows the cicatrized, lead-pipe type of colon but with stricturing at the point indicated by the arrows.

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OBSTRUCTION

Intestinal obstruction in ulcerative colitis occurs with surprising infrequency. This, again, I believe, is due to the fact that the process does not produce its effect locally but diffusely along the tube of bowel, in the beginning involving the mucosa and later infiltrating the muscular coat. This is well illustrated by



Fig. 217. In this illustration haustrations are lost in the descending colon but retained in the ascending and proximal transverse colon. Note the retention of the splenic, sigmoid and hepatic flexures because cicatrization and contraction have as yet not taken place here. This patient had such massive hemorrhage from ulceration of the descending colon that resection of this segment was necessary in the middle of the night.



Fig. 218. This photograph of a removed specimen of ulcerative colitis shows the cicatrized, lead-pipe type of colon but with stricturing at the point indicated by the arrows.

Figure 212, showing a specimen of rigid colon, demonstrating the diffuseness rather than the localizing character of the process.

A type of obstruction which has occasionally occurred in our experience has been stricturing, as shown also in Figure 218 in a completely cicatrized or lead-pipe colon. The infrequency of stricturing in completely cicatrized colons is noteworthy.

I have been impressed over the years with how few adhesions this disease produces within the peritoneal cavity. It appears to be a disease within the bowel, in which extensive ulcerating processes can be present and extensive involvement of the colon wall can have occurred without reactions within the peritoneal coat of the colon and without the establishment of adhesions between the colon and the neighboring structures. I have likewise been impressed as I have done multiple stage removals of the colon over the years, with how infrequently adhesions are found in the gutters after right and left colectomy, when these are investigated after the other procedures are done. Unfortunately, this is not true of the terminal ileum where it is implanted in the abdominal wall for the ileostomy. As one routinely inspects previously established ileostomies during the latter stage of removal of the colon, kinking, angulation and adhesions of the terminal ileum to the parietal peritoneum and neighboring structures are by no means uncommon, and sometimes are troublesome in producing partial obstructions of the ileum proximal to its implantation in the abdominal wall.

JOINT INVOLVEMENT

It has been somewhat astonishing to me that in discussions of the treatment of ulcerative colitis with joint involvement, the establishment of an ileostomy and the removal of the infected colon have not been advocated more often, and that this procedure has not been undertaken earlier in some of the patients who have come to us with ulcerative colitis and joint involvement. We have had a number of patients in whom the complication of joint involvement has been directly associated with, and the result of, the ulcerative colitis, as proved by the prompt disappearance of the joint effects and the return of complete activity with the establishment of an ileostomy and the removal of the colon. Joint involvement is, in our opinion, a definite indication for prompt ileostomy, to be followed by total colectomy and abdominosacral removal of the rectum when it is involved in the disease. I believe this very strongly even though the ulcerative colitis is being successfully managed by nonsurgical procedures as a means of terminating joint involvement and avoiding later irreversible joint changes. It is wrong to delay operation in such cases until joint cartilages are destroyed and damages to the joint are of such extent that even though the infecting agency, the colon, be removed, complete joint motion and full activity cannot be restored. We have now dealt with a number of patients with ulcerative colitis with joint involvement of such extent that joint motion and physical activity were limited to the use of crutches, who were completely restored to full joint motion and general activity with the establishment of an ileostomy and the removal of the involved colon.

MULTIPLE ANAL FISTULAS AND RIGID ANAL SPHINCTERS

Since a majority of patients with ulcerative colitis will have involvement of the rectum, in a number of cases multiple anal fistulas will be present, directly caused by the infiltration of the process in and about the anal canal. There are two extremely undesirable features to this complication. One is the constant soiling about the anus by discharges from the fistulas, with skin irritation; the second is that as these fistulas produce induration of the perianal tissues, the consequent induration results in rigidity and ineffectualness of the anal sphincters. This brings about inability to control the liquid movements that are associated with rigid walled colons and rectums, and this is in itself, I believe, a definite indication for ileostomy, to be followed by colectomy and abdominosacral removal of the rectum. In connection with the problem of multiple anal fistulas and rigid anal sphincters as indications for surgical intervention in ulcerative colitis, I would like to state from personal experiences that no anus can be so involved, no fistulas so multiple and no perianal tissue so rigid that such rectums and ani cannot be excised and reasonably good wound healing obtained—such is the local resistance of the adjacent area to the involved area and the infecting agents which produce it. It is well to advise patients who have had abdominosacral removals of their rectums for involvement of that segment of the bowel by ulcerative colitis that for several months after operation, unlike the permanent healing in patients having this operation for carcinoma of the rectum, there may occur local small accumulations in the perineum which will require drainage, and sinuses which may persist sometimes for several months. All of these complications eventually disappear.

MALIGNANT DEGENERATION

Increasing experience with ulcerative colitis has given rise in everyone's mind to an increasing apprehension concerning the danger of malignant degeneration in ulcerative colitis, since this is a disease in which destruction and repair with metaplasia and neoplasia are constantly going on (Fig. 219). Whether or not, as I have thought, ulcerative colitis increases the incidence of malignant degeneration in these colons, whether or not the incidence of malignant degeneration in a colon which is the site of such metaplasia and neoplasia is no higher than the incidence of this disease in patients with otherwise normal colons, there is no doubt whatever that the opportunity to cure those patients who do have malignant degeneration in a colon which is the site of nonspecific ulcerative colitis is very materially less than it is in patients with noninfected colons. The chances of curing such patients are diminished for two very obvious reasons. One is that, not unlike malignant disease in the breast when associated with an inflammatory process, the ability to obtain satisfactory five-year survival rates is markedly diminished in patients with this same inflammation associated with ulcerative colitis. Second, it is diminished because in a patient with ulcerative colitis the symptoms which make the early diagnosis of carcinoma of the rectum or colon possible are confused by the symptoms of ulcerative colitis. The three signal symptoms by which one may be made suspicious in patients with carcinomas of the colon and rectum—the passage of blood, the alteration in bowel

function and obstructive pain—are no longer useful since they are altered by the symptoms of ulcerative colitis.

Whether or not the incidence of carcinoma of the colon is increased in patients with long-standing ulcerative colitis, as everyone interested in the disease believes, I know that of 18 patients in our experience with proved and removable carcinoma of the colon associated with ulcerative colitis, only two are now alive without recurrence. These two cases are hardly to be classed with true carcinoma of the colon and rectum in a stage in which it could be diagnosed



Fig. 219. This specimen of a colon was removed from a young girl who had repeated acute episodes and remissions of ulcerative colitis, because of which, and because of hemorrhage, colectomy became urgently necessary. One cannot visualize this specimen with the evidences of destruction and repair and the establishment of polyps without being impressed with the added danger of malignant degeneration in this type of process in ulcerative colitis.

in a patient without ulcerative colitis, since they were microscopic findings made by the pathologist in the course of the postoperative examination of the specimen. It could be said that of 16 patients with carcinoma of the colon visually demonstrable after removal, none are alive.

THE MAKING OF AN ILEOSTOMY

The postoperative complications of an ileostomy can be briefly stated. The ileostomies can be too short or too close to the level of the skin, in which case there will be grave danger of contraction. They can be too long, in which case they will project too far through the neck of an ileostomy bag and be irritated by pressure of the rubber wall of the bag against them. They can be badly placed, that is, too close to the umbilicus, in which case the collar of an ileostomy bag (Figs. 222, 223 and 224 cannot be well cemented to the skin around it. They can be too close to the anterior-superior spine, which again will interfere with applying the collar of an ileostomy bag close to the skin. They can be too close to the rib edge, which will result in the same disadvantage. Ileostomies are best placed opposite the umbilicus, a little above the level of McBurney's

point, about a third of the way out toward the anterior-superior spine. A good ileostomy, as shown in Figure 220, has been the type pulled through a stab wound in which there is a completely smooth area of skin about the ileostomy.

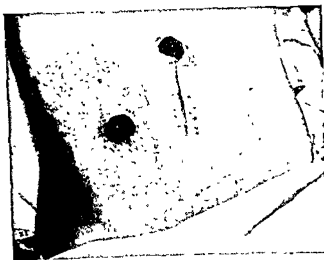


FIG 220. This illustration demonstrates a stab wound ileostomy in the deliberate, divided type of ileostomy as a preliminary step to colectomy. The ileostomy on the right is the func-

It is to be remembered that when ileostomies are implanted through a longitudinal abdominal incision, and I have done a great many this way and still

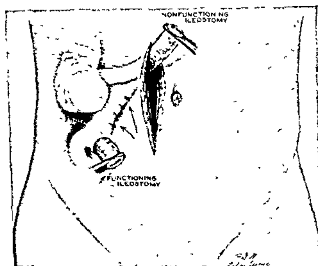


FIG 221. This transparency drawing attempts to show the method of attaching the ileum to the parietal peritoneum with interrupted silk stitches in the deliberate, divided type of ileostomy which is to be followed by colectomy. These stitches, indicated by the arrows, represent in transparency the mesentery sutured to the parietal peritoneum. Note the stab wound ileostomy properly placed and with a completely smooth area of skin about it for good attachment of the cemented flange of the ileostomy bag to the skin. The nonfunctioning segment of the ileostomy is placed in the top of the longitudinal incision.

continue to do so, there are at times certain later disadvantages. Many of these patients are operated upon after having lost up to 100 pounds (Fig. 210). It is to be recalled that with the regaining of their weight they will put on a great

deal of subcutaneous abdominal fat so that the scar of the incision with the ileostomy in it will be represented as a retracted valley to which it will at times be difficult to make the ileostomy bag adhere and not leak, since the bag cannot be held in close contact with the entire skin throughout its circumference around the ileostomy.

Prolapse of the ileostomy can be avoided by suturing the mesentery of the terminal ileum for a not inconsiderable distance to the parietal peritoneum adjacent to the ileostomy with interrupted stitches of silk (Fig. 221), as proposed



Fig. 222. This photograph shows two different sizes of the Rutzen bag with the complete equipment which goes with them, the two tubes of cement, one for the facing of the collar of the bag and the other for the skin, the strap to suspend it and the hook to aid in the removal of the bag for changing. The apertures in these bags, to fit accurately about the ileostomy, are made to correspond to actual measurements, so that there will be no pressure of the edges of the collar on the protruding ileostomy. Note the flanged flat surface which will be cemented to the skin, as indicated by arrows.

by Dr. R. B. Cattell. Retraction of the ileostomy will not occur with a good wound, with a sufficient amount of ileum brought out upon the skin and with the avoidance of skin damage from discharging ileal contents.

One of the most undesirable complications of an ileostomy and one of the easiest complications to bring about is the development of a fistula in the ileum at the level of the skin or at the level of the fascia. Once this fistula into the ileostomy has occurred, with its outpouching of mucosa, I have never seen it close spontaneously and it will require disconnecting the ileostomy completely and the making of a new one. This unhappy complication is usually the result of putting stitches too close to the ileum, inserting them inadvertently through the wall of the ileum or making the closure too tight about the neck of the ileostomy. This is a complication which has occurred to us more than once and can be avoided by greater care in the introduction of stitches about the wall of the ileum as it comes through the abdominal wall. I am convinced that all ileos-

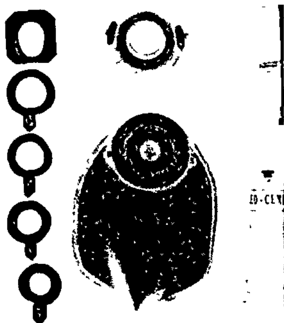


Fig. 223. This is the Torbot bag, also devised by a patient with an ileostomy. It may be noted that the flange which is to be cemented to the skin in this bag is of plastic material. To the left of the bag are the various measuring devices from which one can select a circle which fits easily about the ileostomy, forward this measurement to the manufacturer and obtain a bag with an aperture which will fit perfectly.

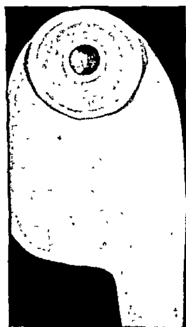


Fig 224. This is the Perma bag, which is much like the other bags with the exception that the flanged collar has an elevated projection so that it tends to project into the soft skin around the ileostomy. This bag has been worn by several patients for as long as a week without leakage and without having to be removed and re-applied.

tomies should be supported in the abdominal wall only by the suture of the mesentery to the parietal peritoneum (Fig. 221), and that under no circumstances should stitches be introduced between the terminal ileum, the peritoneum or the fascia.

Since it is possible to avoid skin damage completely by means of the ileostomy bag if it is made so that it fits accurately to the mucocutaneous edge and leaves no area of skin to be irritated, I see no advantages in the skin grafting of an ileostomy. The ileostomy bag, of which now there are several varieties (Figs. 222, 223 and 224), functions so satisfactorily when the aperture at the neck of the bag, as shown in Figure 223, is made of proper diameter for each case that not only is skin grafting an unnecessary refinement but in more cases than one, when this grafted ileostomy is implanted in the bag, I have seen irritation and ulceration of the grafted wall of the ileostomy occur.

I like to urge that all patients with ileostomies, as with colostomies, have their ileostomies inspected carefully every night for loss of blood supply for at least five days after operation. It will be a rare case in which, as the result of vomiting or coughing, the included mesentery of the ileum will be torn, or as the result of swelling, its blood supply will be limited. If the ileostomy is observed regularly every night for five or six days, there will still be time to remake the ileostomy should this unfortunate event occur, and save the patient from perforation, wound contamination and sometimes peritonitis.

SHOULD ILEOSTOMY AND TOTAL REMOVAL OF THE COLON AND RECTUM BE DONE UPON ALL PATIENTS WITH ULCERATIVE COLITIS?

While one would hardly wish to support such a radical thesis, there are many encouraging aspects to the treatment of ulcerative colitis by ileostomy, total colectomy and abdominosacral removal of the rectum. The first one is that it will completely relieve the patient of the disease, completely rehabilitate him from all of its effects and protect him against any and all of the above-stated complications, including the high hazards of malignant disease of the colon associated with ulcerative colitis. It has the additional advantage that following the removal of the colon, the character of the ileal contents quite materially improves in terms of semisolidity. With the bag cemented to the skin about the ileostomy (Fig. 225), this operation makes life, after removal of all of the involved colon and rectum, unlimited in any of its phases, even permitting, as I have already stated in articles on this subject, marriage, pregnancy and the raising of a family on the part of young women in whom this disease has so frequently occurred I was reluctant when first presented with this problem to permit young women who had had ulcerative colitis and upon whom we had done ileostomies, total colectomies and abdominosacral removals of the rectum, to marry and have children, but a sufficient number of these patients has now gone through pregnancy after ileostomy, colectomy and abdominoperineal removal of the rectum so that I do not believe that it adds an unreasonable amount to the hazard of that undertaking.

Even though we have managed a considerable group of patients with ulcerative colitis quite satisfactorily under a medical plan, such has been the satis-

faction of patients with ulcerative colitis who have had their entire colons removed and ileostomies made that I would not, and do not, hesitate to advise total colectomy in all patients who have had ileostomies. The mortality of this operation in patients who have already had ileostomy is very low in experienced hands and the benefits in protection from complications and, particularly, super-

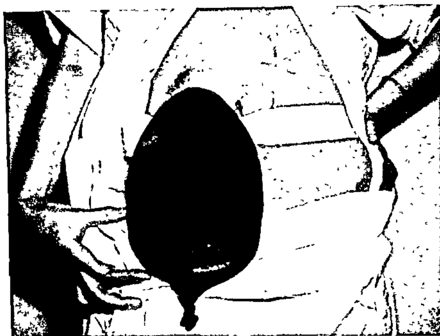


Fig. 225. An ileostomy bag is shown in place and cemented to the skin. This illustration is shown particularly to indicate the proper location at which to make the ileostomy so that it will not be too close to the umbilicus, too close to the anterior-superior spine or too close to the rib. These bags are flat and can be worn with tight-fitting dresses or trousers without disfigurement.

imposed malignant disease are well worth the investment in time, risk and relatively short disability.

CONCLUSIONS

Some of the causes of the high mortality and disturbing complications of the past in patients with ulcerative colitis are discussed in the light of the improvements in the management of this disease and its complications in later years.

Under nonoperative management are discussed our experiences with ACTH in converting patients in acute phases of the disease into remissions.

Attention is called to the need for early ileostomy in those patients in acute stages of this disease whose condition is not promptly converted to remission by this agent.

The problem of blood loss in patients with ulcerative colitis is considered, and the occasional need for emergency ileostomy and colectomy in this complication is discussed.

Perforation as a complication and its management are discussed, as is obstruction. Joint involvement and early removal of the colon as a means of avoiding permanent joint damage and resulting disability are discussed, as are multiple anal fistulas and the rigid, incompetent anal sphincter.

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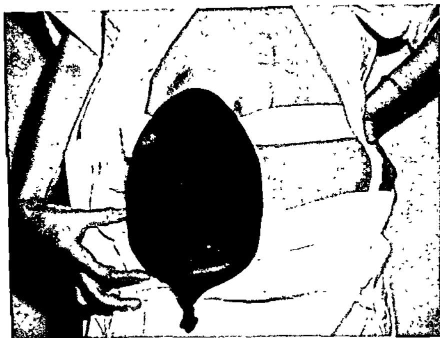


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Cancer in patients with ulcerative colitis and the poor outlook for a cure when this occurs are discussed.

The making of a successful ileostomy and some of the ways of doing it and avoiding complications with it are discussed.

The types of ileostomy bags are illustrated.

Colectomy is advised for all patients who have had a permanent ileostomy established.

POLYPS OF THE COLON AND RECTUM

NEIL W. SWINTON AND JAMES H. HOLT

The subject of rectal and colon polyps is of particular interest because of the intimate relationship of these tumors to malignant disease of the terminal bowel (Tables 1 and 2). There is general agreement on the basic phases of

Table 1. Incidence of Polyps in Colon and Rectum
(1935–1945—1843 Autopsies)

130 patients had 311 polyps (7%)
42% had multiple polyps
58% had single polyps
195 patients had 207 malignancies (10%)
25% had associated benign polyps

Table 2. Incidence by Location of Benign Polyps and Malignancies of the Colon
(1935 to 1945 Autopsy Series)

	MALIGNANCY		BENIGN POLYPS	
LOCATION	Cases	Per cent	Cases	Per cent
Cecum, Ascending colon	27	13.0	64	20.5
Hepatic flexure, Transverse colon, Splenic flexure	28	13.5	85	27.3
Descending colon, Sigmoid, Rectum, Anus	152	73.5	162	52.2
Total	207		311	

this subject. Colon and rectal polyps occur in people of all ages, with an increasing incidence in the older age groups. They are frequently multiple. There is a definite similarity between the age incidence and location of adenomas and carcinomas. Certain malignant tumors of the large bowel are known to develop without formation of a benign adenoma but it is generally believed that the majority of malignant tumors of the colon and rectum originate in pre-existing benign adenomas. Rectal and colonic adenomas are true tumors because of some inherent defect in their cellular growth and not the result of an inflammatory process. They are potentially malignant lesions and should be removed or destroyed whenever encountered.

In this presentation emphasis will be given to some of the experiences which we have had in the detection, differential diagnosis and management of rectal and colon polyps at the clinic. A review has been made of 300 patients with benign rectal and colon polyps treated by us between the years 1935 and 1945.

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Descending colon Sigmoid Rectum Anus	152	73.5	162	52.2
Total	207		311	

this subject. Colon and rectal polyps occur in people of all ages, with an increasing incidence in the older age groups. They are frequently multiple. There is a definite similarity between the age incidence and location of adenomas and carcinomas. Certain malignant tumors of the large bowel are known to develop without formation of a benign adenoma but it is generally believed that the majority of malignant tumors of the colon and rectum originate in pre-existing benign adenomas. Rectal and colonic adenomas are true tumors because of some inherent defect in their cellular growth and not the result of an inflammatory process. They are potentially malignant lesions and should be removed or destroyed whenever encountered.

In this presentation emphasis will be given to some of the experiences which we have had in the detection, differential diagnosis and management of rectal and colon polyps at the clinic. A review has been made of 300 patients with benign rectal and colon polyps treated by us between the years 1935 and 1945.

Additional data have been taken from patients treated during the past five years. It is estimated that during the year 1950, between 150 and 200 patients with benign rectal and colonic polyps will have been treated.

INDICATIONS FOR THE EXAMINATION OF PATIENTS FOR THE DETECTION OF BENIGN MUCOSAL POLYPS

Benign mucosal polyps of the terminal bowel will not be discovered in appreciable numbers if examinations of this region are confined to those patients with the classical symptoms of rectal bleeding, alterations in bowel function and unexplained abdominal pain. It is our policy to include a sigmoidoscopic examination of all patients coming to the clinic for a complete physical examination. Benign polyps are being found in 5 per cent of all patients examined. It is difficult to determine accurately the percentage of benign polyps which cause symptoms because of the frequent association of anorectal disease, but it is our estimate that not over 20 per cent of patients with benign polyps have associated bleeding or other referable symptoms. The increase in the number of benign polyps detected in our patients is in direct proportion to the number of sigmoidoscopic examinations being performed, regardless of symptomatology.

METHODS OF EXAMINATION

All patients who come to the clinic are given a complete physical examination which includes a digital examination of the rectum. A few patients are sigmoidoscoped immediately without bowel preparation. These patients may have active colitis, or some other intra-abdominal inflammatory condition, obvious bowel obstruction or an easily palpable large rectal tumor. The majority of patients, however, when organic disease of the terminal bowel is to be ruled out, are carefully prepared before instrumental and radiographic studies are made.

One and one-half to 2 ounces of castor oil is taken the night before the examination. On the morning of the examination a colonic irrigation, not an enema taken by the patient at home, is given under trained supervision. One to two hours after the colonic irrigation has been evacuated, the sigmoidoscopic examination is done with the patient in an inverted position. It is important, especially in the training of younger physicians, to emphasize that the anal canal must also be visualized with the anoscope, preferably with the patient in a Sims' position, following the sigmoidoscopic study. The importance of the anal canal as the origin of rectal bleeding must never be overlooked. This region is not visualized accurately with the longer examining instruments when the patient is in an inverted position A high percentage of our patients have radiographic studies of the colon made on the same day. Such a study should be delayed two to three hours following the sigmoidoscopic examination so that the influx of air into the colon may be evacuated and will not interfere with the radiographic studies of the colon.

We have previously reported in detail our technic of radiographic studies of the terminal bowel. We are not satisfied with the number of polyps which are being discovered by radiographic means in that portion of the bowel above

the reach of the 10 inch or 25 cm. sigmoidoscope. The bowel must be empty. The examination must be done by a skilled and experienced radiologist. It is our policy to perform the usual routine barium enema study at the first examination. The solution which we have been using most recently is a barium sulfate enema containing 1 cup of barium sulfate plus 2 teaspoonfuls of tannic acid to each quart of warm water. Careful fluoroscopic studies are made and films are taken in the posteroanterior and oblique positions and frequently lateral views of the ampulla are also made. Additional films are taken after the evacuation of the colon.



Fig 226. Demonstration of mucosal pattern of colon with contrast air technic. Note moderate sized polyp with pedicle in descending colon.

There has been considerable misinformation in the literature on the value of the contrast air technic. We have discovered in many instances small benign polyps in the colon with the use of the contrast air studies (Fig. 226) that were not found with the ordinary barium enema, but if such studies are to be made they should be made only in addition to the usual barium enema examination. Contrast air studies should be made at a separate time and following a separate and second bowel preparation.

We still see patients at the clinic who have had negative barium enema studies of the colon with lesions that can be visualized with the sigmoidoscope. A statistical study of patients sigmoidoscoped for bleeding and other symptoms or as a part of a routine physical examination is shown in Table 3. It may be noted that whereas in 15 patients polyps were visualized on *sigmoidoscopic* examination, these findings could be corroborated by radiographic means in

only 5. In one instance, however, a polyp in the rectosigmoid area which had been overlooked at sigmoidoscopy was detected on roentgenologic examination. Radiologists should insist that, when organic disease of the colon or rectum is suspected, a sigmoidoscopic examination of the terminal bowel be made before radiographic studies of the colon are performed.

Most sigmoidoscopic examinations at the clinic are performed by general surgeons with some special interest in the field of proctology. Many routine examinations, however, are done by gastroenterologists and by younger internists and surgeons in training.

Surgeons in general are aware of the necessity and value of sigmoidoscopic examinations, but internists and all physicians doing general diagnostic work must also fully appreciate the importance of examinations of this type.

Table 3. Radiographic Studies of Colon and Rectum
(Barium Enema and Contrast Air Technics)

	NUMBER	PER CENT
1. Patients studied	150	
2. Patients with bleeding (23 *with hemorrhoids or fissure*)	62	41
3. Investigation of other symptoms	88	59
4. Polyps visualized with sigmoidoscope	15	
5. Polyps visualized by radiograph	5	
6. Total patients with polyps	16	

Of the many thousands of sigmoidoscopic examinations performed at the clinic, until one month ago there had never been a serious complication. We have now experienced our first bowel perforation. The patient was an 85-year-old woman being sigmoidoscoped for upper abdominal symptoms. Without apparent cause, the anterior wall of the sigmoid colon was perforated during the sigmoidoscopic visualization of this region. At operation the only reason that could be discovered for this unfortunate accident was the atrophic muscle wall of the large bowel which is so commonly seen in aged patients. As a result of this complication extreme caution is now being taken in performing sigmodoscopic examination on patients in the aged group, as well as in children, and in addition, on those patients with inflammatory conditions, such as ulcerative colitis, stricture and obstruction of the colon.

All physicians in training in both our surgical and gastroenterologic divisions are being trained in the use of the sigmoidoscope. We believe that in the basic training of all physicians there should be a general acceptance of the attitude that the sigmoidoscope should be as familiar to the examining physician as is the stethoscope and other diagnostic instruments of this type.

In the past six months perforation of the large bowel resulting from the introduction of barium into the colon has occurred in 2 patients with obstructing lesions of the colon. The escape of the opaque medium from the bowel was detected in both instances during the fluoroscopic visualization of the introduction of the barium, and operation was immediately performed. This complication must always be considered during radiographic studies of the gastrointestinal tract when obstructive or inflammatory lesions are present.

CLINICAL AND HISTOLOGIC TYPES OF RECTAL AND COLONIC POLYPS

In this discussion, the term polyp is defined as a tumor arising from the mucous membrane of the colon or cecum (Fig. 227). Hypertrophied anal

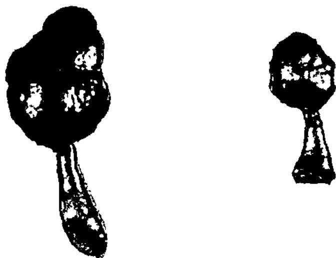


Fig. 227. Typical adenomatous polyps with pedicle. These adenomas were removed from the sigmoid by colotomy.



Fig 228. Typical papillary adenoma or villous type tumor. This tumor was removed from the sigmoid region of the colon by segmental resection.

papillae, hemorrhoids or other tumors arising in the anal canal are not included. Polyps may be sessile or pedunculated. The majority are adenomatous in character and properly should be referred to as adenomas. Our pathologists report all benign tumors of this type as mucosal polyps without further differentia-

tion. From a clinical standpoint, particular attention must be given the papillary adenomas or villous tumors (Fig. 228) because of their differences in behavior from the usual adenoma—most importantly, their tendency to local recurrence.

In our group of 300 cases reviewed for this report 20 patients had papillary adenomas, an incidence of 6.6 per cent. Since 1945 there has been an additional number of patients with this type of tumor. After reviewing our cases and again reviewing the reports of Sunderland and Binkley on this subject, we realize that our experiences closely parallel those of the Memorial Hospital and there is little that we can add to their published discussion of this subject. The basic difference between papillomas and adenomas is in their manner of growth. As Binkley has stated, "whereas the adenoma is a tumor of mucosal glands with little if any involvement of the surface epithelium, the papilloma is the reverse, a tumor primarily of the mucosal surface epithelium with resulting secondary glandular changes, also that the tendency for growth in the papillomas is of progressive lateral spread." We have never observed a minute papilloma, have invariably found some degree of underlying glandular involvement in these tumors, and have found them in an older age group than that in which adenomas are found. When malignant change takes place in these villous tumors, the carcinoma develops in the deep or glandular portion of the tumor.

THE DIFFERENTIAL DIAGNOSIS OF MALIGNANT DISEASE

The detection of invasive cancer in either the adenomas or papillary adenomas is well understood by both surgeons and pathologists who have had extensive experience with this disease. It is still a common occurrence at the clinic, however, to see patients referred to us with a diagnosis of low grade malignant disease of the rectum or colon, based on histologic study of a biopsy specimen. As a result of our histologic and clinical investigations we are unable to agree with the previously reported diagnosis of malignant disease in many of these patients.

Tumors within reach of the examining finger or easily palpated by the examining instrument, which present induration, fixation, firmness and ulceration, must always be considered to be malignant (Fig. 229). Shields Warren and Swinton, in 1939, presented the histologic criteria of malignancy for tumors of this type which, we believe, have withstood the test of time. Warren stated that "if we accept three important criteria of malignancy—anaplasia, irregularity of architecture and invasion—it is necessary to have at least two of these three factors present before making a diagnosis of malignant disease. It is possible for any of these three criteria to be present without actual malignancy with one exception, definite lymphatic or intravascular invasion means clinical cancer." Meissner, in a more recent publication, has added certain other criteria. He stated, "Cancer must not be diagnosed on the mere presence of numerous mitoses in the tumor. Benign polyps often show many mitoses. Epithelial cells often occur within vessels as artefacts produced by cutting the tissue. For the diagnosis of cancer, the intravascular epithelial cells should at least be associated with a thrombus and preferably be actually invading the vessel wall. All portions of the biopsy specimen must be examined (Fig. 230) before a negative report

is made. Otherwise, a small focus of malignant change may be overlooked. The diagnosis of cancer should never be made on borderline evidence. A pathologist

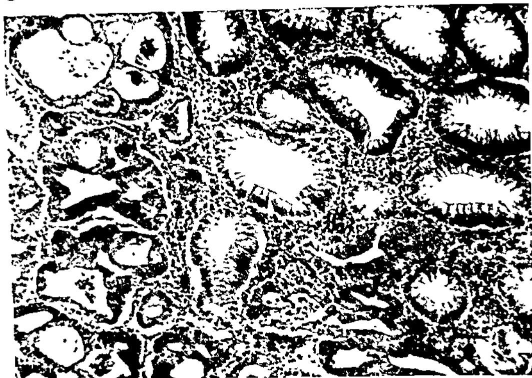


Fig. 229. Mucosal polyp or adenoma of rectum with early invasive adenocarcinoma.



Fig 230. A cross section of benign mucosal polyp or adenoma together with its stalk. Malignant degeneration may develop in any portion of this tumor. Histologic examination must be made of all portions of the tumor to determine accurately the presence or absence of cancer.

should not feel compelled to diagnose tissue which is inadequate. Both the clinician and pathologist must appreciate that repeated biopsies may be neces-

sary before a definite decision can be made." It is needless to add that in a study of any tissue of this type, a review must be made of the entire tumor together with its base before malignant disease can be excluded.

It has been our experience that the determination of malignant degeneration in these tumors is frequently difficult and not well understood by many pathologists.

TREATMENT OF BENIGN RECTAL AND COLONIC POLYPS

The majority of the polyps found in our series of 300 patients were small adenomas encountered in the rectum on sigmoidoscopic examination, and

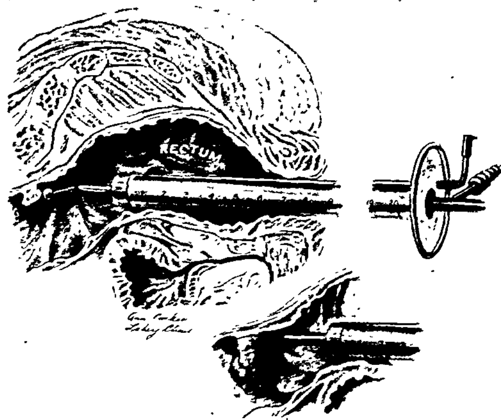


Fig. 231. Diagrammatic illustration of fulguration of a benign adenoma. When a definite pedicle is present, the tumor may be removed in its entirety with a high frequency electric snare.

many were destroyed by fulguration (Figs. 231 and 232) without biopsy. In our series of cases the following data are of significance.

Eight patients were under 20 years of age. It is to be noted that few children are treated at the clinic. The largest number of patients, 101, were between the ages of 51 and 60. Sixteen patients were over 70 years of age. There were 166 males and 134 females In 223 patients the lesions were single and in 77 multiple. This compares with our previously reported autopsy series of an incidence in males of 63 4 per cent and an incidence of multiple polyps in 41 per cent of patients.

The location of the 331 polyps found in these 300 patients was as follows: rectum, level not given, 24, within 3 inches of the anal orifice, 92, 3 to 6 inches

from the anal orifice, 128; 6 to 10 inches from the anal orifice, 40. Thirty-three were in the sigmoid, 3 in the descending colon, 3 in the ascending colon, 6 in the transverse colon and 2 in the cecum. The size was recorded in 313 instances: less than 0.5 cm. in diameter, 136; 0.5 to 1.5 cm. in diameter, 96; over 1.5 cm. in diameter, 81. Clinically, the polyps were classified as adenomatous in 284 and papillary adenomatous in 20 instances, the classification was not given in 27 instances.

The pathologic diagnosis in this series was as follows: benign mucosal polyps, 163; benign mucosal polyps with localized carcinoma, 33, no pathologic change



FIG. 232. Inverted position for sigmoidoscopic examination. The fulgurating tip is being utilized for fulguration of small benign mucosal polyp. Note the built-in suction attachment for removal of smoke and liquid bowel content.

reported, 104. In addition, 48 patients had associated carcinoma of the rectum, 18 associated carcinoma of the colon and 10 associated ulcerative colitis.

Treatment of the polyps in this series was as follows: fulguration only, 140; multiple fulgurations, 10 (most of these patients had the papillary adenomatous type of tumor); snare excision and fulguration, 35; surgical excision, 34; colotomy, 26; radical resection, 62; not treated, 4.

It has been our policy to fulgurate, without biopsy, with the high frequency unit those small adenomatous polyps which are easily reached with the sigmoidoscope, are below the peritoneal reflection and obviously benign. To date we have had no reason to regret this attitude.

We have removed with the high frequency electric snare those polyps with a definite pedicle which can easily be reached even though they may be above the peritoneal reflection and in which the base of the pedicle can be approached without difficulty and is clearly observed. Those polyps at a high level which

cannot easily be reached or in which the entire pedicle cannot be clearly observed are removed by sigmoid colotomy (Figs. 233, 234 and 235). Obviously, those tumors detected by radiographic studies of the colon will also be removed by colotomy. We have had no experience in the treatment of tumors of this type with the local application of radium or high voltage therapy.

Our principal problem in the treatment of these tumors has been with the management of the papillary adenoma since we are constantly aware of the tendency, as stated by Binkley and others, of these tumors to recur.

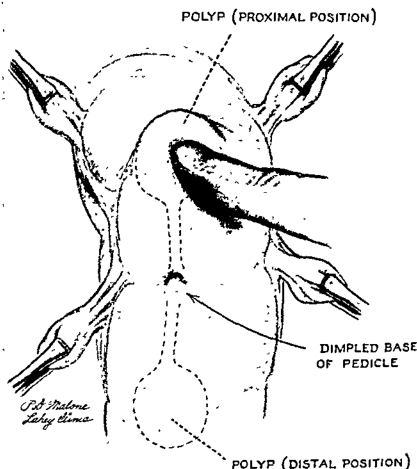


Fig. 233. Method of determining mode of attachment of pedicle. Polyps in the left colon frequently have a pedicle several inches in length. The longitudinal incision in the bowel for the removal of these tumors should be made at a point midway between the two extremities of the polyp, as noted in the diagram. (From Am. J. Surg., 76 733, December, 1948.)

Six of the 20 patients with papillary adenomas have had repeated recurrences, one patient over a fourteen-year period. In 3 additional patients invasive carcinoma ultimately developed and they required radical resection. Five of the 20 patients have not been followed recently.

Three patients in this series were treated by resection, 7 by local excision and the remainder by local and usually repeated fulgurations. It has been impossible to prognosticate which of these tumors will tend to become malignant (undoubtedly some of them will eventually) and which will tend to recur

locally. Binkley has emphasized that in his experience "no tumor that showed a uniformly benign structure originally and in the early recurrences has developed infiltrating carcinoma to date." Our tendency at the present time in the treatment of these papillary adenomas is to consider some type of resection for more and more of them.

Buie has reviewed in detail his vast experience with the fulguration of rectal tumors. We do not disagree with his policies except that in our opinion, with

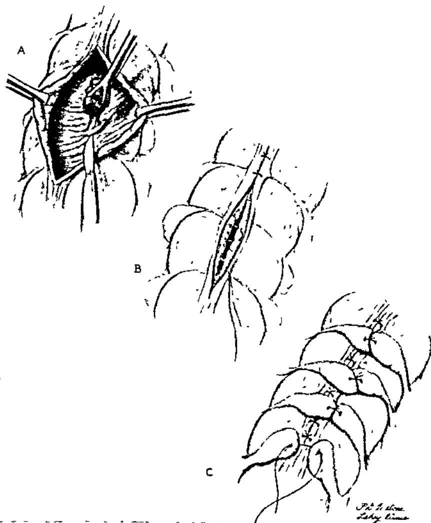


Fig. 234. Diagrammatic illustration of the removal of a benign mucosal polyp or adenoma with pedicle of the colon. (From Am. J. Surg., 76:733, December, 1948.)

experienced surgeons and when all facilities for any type of treatment are available, tumors which can be clearly seen and are within reach of the 10-inch instrument can be treated locally in most instances. In our entire experience there have been only two instances of bowel perforation following fulguration. In one of these, entirely too much tissue was destroyed at a single sitting by an inexperienced surgeon. The second perforation was a subacute process and occurred during the fulguration of a small, deep-seated, obviously malignant tumor. The fulguration was done to control bleeding following a biopsy and immediate resection was performed without difficulty.

A word may be said on our present attitude toward the treatment of the congenital type of multiple polyposis. This subject is, in general, well understood. In the past all of these patients died of cancer; the oldest recorded patient in our experience died at the age of 49 years. At the clinic treatment has consisted of ileosigmoidostomy and resection of the colon, with fulguration of all polypoid tissue in the rectum, usually preceding the anastomosis of the ileum

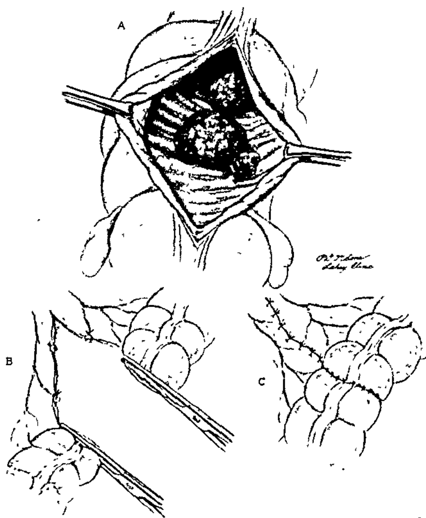


FIG. 235 Diagrammatic illustration of segmental resection of the colon for a cluster of polyps or a polyp in which infiltration of malignancy into the base of the polyp is suspected (From Am. J. Surg., 76 733, December, 1948.)

to the rectal segment. As these patients have been followed over the years, however, carcinoma of the rectum has already developed in 2 patients in our series. These were patients in whom it was not possible to conduct follow-up examinations at frequent intervals. Because of this experience and because others have reported a similar experience, we believe that unless patients with this disease can be closely followed the most desirable treatment may be removal of the entire terminal bowel rather than the retention of a rectal segment.

A word may also be said on the subject of polypoid disease associated with chronic ulcerative colitis. We do not believe that the pseudopolyposis resulting from inflammatory processes as seen in chronic ulcerative colitis has any rela-

tion to malignant disease. It has long been recognized, however, that cancer of the colon is common in the patient with chronic ulcerative colitis and when malignant degeneration does develop, its progress is usually rapid and fatal. If one appreciates that approximately 5 per cent or more of the adult population have true adenomas and that the irritative effect of the colitis may increase the rapidity with which malignant degeneration occurs in these tumors, the frequent occurrence of cancer in chronic ulcerative colitis can perhaps be explained.

FOLLOW-UP STUDIES

Follow-up studies in patients who have had benign polyps of the terminal bowel have been of particular interest to us, not only from the standpoint of the incidence of recurrent tumors and the subsequent development of malignant disease, but also from the economic aspect of the repeated examinations. The preparation of these patients, sigmoidoscopic examinations and radiographic studies of the colon are not to be taken lightly. They are time-consuming procedures and expensive for the average patient.

In our experience, an adenoma of the rectum or colon has never actually recurred when the entire tumor has been removed, its base fulgurated and our pathologists have reported it as a benign mucosal polyp. Because of the known multiplicity of these tumors, because of the known inaccuracies of radiographic studies of the colon and because in our series of 300 patients we found subsequent polyps in 12 and subsequent cancer in 10, these patients must have careful follow-up examinations.

When a benign mucosal polyp has been destroyed by fulguration or removed with a high frequency snare, it is our policy to re-examine these patients in six to eight weeks to be certain that the polyp has been completely destroyed or removed. Usually, complete healing will have occurred. If healing is not complete in this length of time, further biopsies should be performed. An examination is usually again made in from three to six months' time, and on either of the first or second follow-up examinations, radiographic studies of the colon are made. If additional polyps are not found on two or three examinations during the first year, the chance of finding polyps in these patients is not great but, based on our present knowledge, we advise these patients to have check-up examinations at one or two year intervals.

It has been our experience that 25 per cent of patients who have resections for carcinoma of the colon or rectum have associated benign polyps. It is in this group particularly that follow-up studies should be made indefinitely to prevent the subsequent development of malignant disease. Sidmoidoscopy should be performed, through the colostomy stoma if necessary and when possible, and the patients should have careful follow-up radiographic studies. These studies are repeated at least twice during the first postoperative year and annually thereafter.

In regard to those patients who come to us for complete physical examinations who do not have rectal or colon symptoms, in whom a routine sigmoidoscopic examination and a radiograph of the bowel is negative, it is our policy

to repeat these studies not oftener than at two-year intervals. These tumors are slow growing, and examinations at more frequent intervals than this probably are not necessary.

In a follow-up of the 300 cases reported it was not possible to obtain recent data on 70. One hundred and twenty-five were followed for over five years without evidence of further trouble, and 88 for less than five years without further polyp or cancer formation. Twelve patients were found to have subsequent benign polyps although, as we previously inferred, these were additional polyps, probably in some instances overlooked at the original examination. Cancer developed subsequently in 10 patients and 14 died of causes which were obviously other than disease of the colon or rectum. There were 8 postoperative deaths, 6 of which were from malignant disease. Twenty patients died of cancer, 18 of whom had malignant disease at the time of operation.

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SURGICAL TREATMENT OF POLYPS OF THE LARGE INTESTINE

RICHARD B. CATTELL

The discovery and treatment of intestinal polyps while still in a benign or premalignant state are of the utmost importance. The destruction of polyps in the lower segments by fulguration or their removal from the proximal segments by laparotomy permits local removal usually without the necessity for removal of large segments of the intestine which becomes necessary when malignant degeneration has occurred. Careful study of adults during a routine physical examination, which includes sigmoidoscopic examination and roentgenographic studies of the colon, will result in the discovery of an increasing number of these benign lesions. Major attention has been focused properly upon the detection of carcinoma of the colon and rectum in as early a stage as possible since adequate resection offers an excellent chance for cure in this stage of malignancy.

In spite of the fact that malignant lesions are being resected at a somewhat earlier time, which in our experience is approximately a two months shorter duration than ten years before and in spite of improvements in operative procedures for removal of the malignancy and reduction in operative mortality, the results observed five years or more after resection have not appreciably improved and remain in the vicinity of 50 per cent five-year survivals. The greatest opportunity in the future for the improvement of results lies in the discovery and treatment of the premalignant lesion of the colon and rectum, the benign polyp. It is encouraging to see the increased emphasis being placed on the importance of the benign intestinal polyp.

Experiences in the treatment of polyps of the large intestine at the Lahey Clinic have been presented in several communications.[1, 8–10] Over 1,000 polyps of the rectum and rectosigmoid have been treated while seventy-eight patients have been submitted to colotomy for removal of polyps in the proximal segments of the colon. In addition, 23 patients have been operated upon for congenital polyposis. No statistical analysis will be presented but general considerations will be discussed and the operative procedures that have been employed will be outlined.

GENERAL CONSIDERATIONS

The incidence of polyps of the intestine is quite difficult to determine and depends upon the material analyzed; it has varied from 2 to 20 per cent in reported series. In autopsy series of adult patients which must be considered a selective group Swinton and Haug[9] found 7 per cent in 1,843 patients, or 311 with benign mucosal polyps. Helwig[5] found 9 5 per cent. As high as 40

Originally published in American Journal of Surgery, 76 733–742 (Dec.) 1948.

per cent of patients have multiple polyps. Approximately 25 per cent of patients with malignancies have benign polyps found in the resected specimen. If one takes a special group of patients seeking proctologic consultation because of rectal symptoms, the incidence is between 5 and 10 per cent. It is probably safe to assume that at least 3 per cent of adult patients have benign polyps.

In view of the fact that only one-third of patients with benign polyps have symptoms it is immediately apparent that discovery of polyps in the remaining two-thirds of patients will be possible only when increasing numbers of sigmoidoscopic examinations are done in the routine examination of adult patients and this is recommended very strongly. This is one step in preventive medicine



Fig. 236. *A*, Barium enema (full) showing radiolucent defect of large polyp in descending colon, B, double contrast air enema outlining mucosal surface and pedicle of the polyp.

that offers real promise in reduction of the incidence of carcinoma of the large intestine which represents approximately one-eighth of malignancies.

Intermittent or persisting bleeding is the only common symptom associated with benign polyps and this symptom occurs in only one-third of the patients. A few complain of increase in the discharge of mucus and in the occasional patient with a villous polyp a watery discharge may be present. At times, because of the large size of a polyp or because of partial intussusception, obstructive symptoms will be present.

Diagnosis of polyps of the rectosigmoid and rectum, where over one-half of them occur, should not be difficult. Adequate preparation of the bowel is essential and is best accomplished by castor oil or magnesium sulfate given the night before with cleansing enemas or colonic irrigations given one or two hours preceding the sigmoidoscopic examination. Too often attempts are made to do sigmoidoscopy with fecal material remaining in the bowel. Under these circumstances, when all of the mucosal surface cannot be visualized properly, small polyps are easily missed. Visualization of polyps in the proximal colon offers much greater difficulty. The same means of adequate preparation of the bowel

are even more essential. Both the barium enema and double contrast air enema should be utilized (Fig. 236). We have seen many patients in consultation referred for treatment of multiple polyposis who on further examination were found to have a normal colon. The addition of tannic acid to the barium mixture in carrying out the contrast air enema is very useful. At least one repeat examination should be done for every patient discovered to have a colonic polyp to be certain that it can be visualized on second examination at the same site. This rule of repeated examinations will save the embarrassment of an appreciable number of negative abdominal explorations.

The surgical treatment of intestinal polyps can be divided into three groups: (1) polyps of the rectum and rectosigmoid, (2) colonic polyps and (3) congenital polyposis.

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all fecal material has been removed. In one patient operated upon during the last year, in spite of the usual preparation, the colon was poorly prepared and the polyp could not be found. After further studies to make certain that the polyp was present reoperation was necessary for its removal. Adequate preparation should avoid this disturbing occurrence.

We utilize spinal anesthesia, either with the single dose method with pontocaine weighted with glucose or fractional spinal, for carrying out operative procedures for the removal of polyps. This permits the greatest possible ease in complete exploration of all of the colonic segments which is so important in view

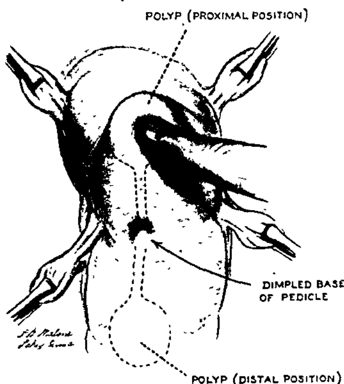


Fig 237. The sigmoid has been freed and the polyp located. The diagram shows polyp being displaced proximally with a dimple appearing at its attachment.

of the multiplicity of polyps. General anesthesia supplemented with curare may likewise produce satisfactory operative condition.

Since most polyps are located in the descending colon or sigmoid, exploration is carried out through a left rectus incision. Complete abdominal exploration is carried out. All segments of the colon are carefully explored for any possible additional lesions. In one patient a large polyp in the descending colon had been demonstrated easily without other lesions being evident in the roentgenogram. This polyp was easily felt but at the time of exploration an early carcinoma was felt in the right colon, emphasizing the importance of this careful exploration.

Particular attention is paid to exploration in the area suspected of containing the polyp. This is best accomplished after detaching the parietal peritoneum and severing the fascia propria which anchors the mesocolon posteriorly. The polyp frequently will be found some distance from where it appears in the roentgenogram either because of a long pedicle or because of distortion in the

film. Palpation of the bowel is best done with the finger passed longitudinally along the bowel pressing it back against the mesentery (Fig. 237). This avoids the rounded appendices epiploicae or diverticula which may be encountered and may simulate polyps. After identifying the position of the polyp this segment of the bowel may be held by four clamps or traction sutures on the appendices

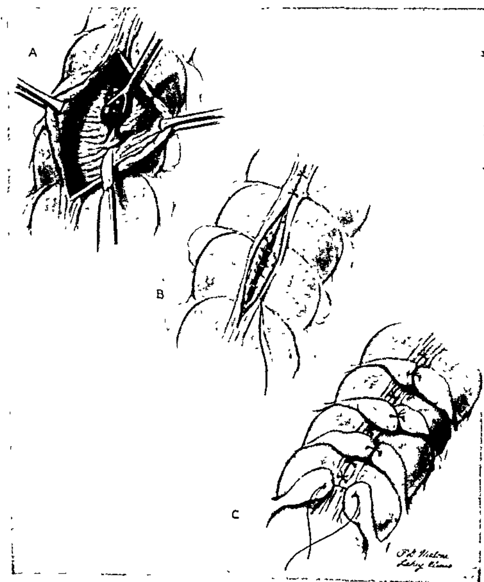


Fig. 238. *A*, Incision has been made on the amesenteric side of sigmoid through a longitudinal band, the polyp elevated and excision begun; *B*, mucosa is being inverted with continuous suture and approximation sutures begun of seromuscular coat; *C*, suture line completed with appendices epiploicae approximated to reinforce the suture line.

epiploicae. The polyp should then be displaced as far proximally as possible (Fig. 237) and the area on the bowel marked. The procedure is repeated displacing it distally, and a point selected midway between the two extremes for incision into the colon. Since most of the polyps in the colon are pedunculated and can be visualized by roentgenographic means, this maneuver will greatly aid in their identification and removal. The pedicle of the polyp can frequently be felt if the attachment of the pedicle is on the amesenteric wall. When it is displaced, a dimple will appear (Fig. 237) which should be included in the in-

cision. If *it is attached to the posterior or mesenteric wall,* the base cannot be definitely identified. Palpation may demonstrate induration of the base. If this is present, primary resection and anastomosis are performed without biopsy.

A longitudinal incision is made at the point selected, spreading the muscularis before opening the mucosa. This leaves a large amount of mucosa exposed to permit satisfactory inversion at the time of closure. *The polyp is elevated and*

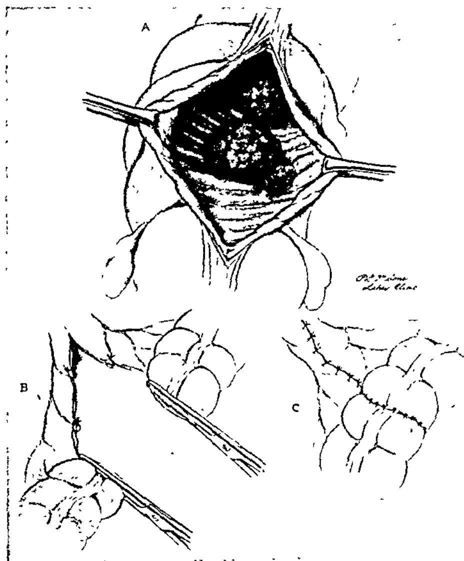


Fig 239. *A,* Colotomy incision exposed multiple polyps; *B,* segmental resection performed, *C,* end-to-end anastomosis completed.

inspected, with particular attention paid to the mobility and freedom of the base (Fig. 238, *A*). *The pedicle is widely excised beyond a clamp,* followed by suture ligature ligation or actual suture closure, including the mucosa and submucosa. Immediate frozen section should be done with particular attention paid to section through the base.

If the polyp is large and spreading, even though it is proved benign after opening the bowel and doing a biopsy, local resection should be started with end-to-end anastomosis (Fig. 239, *A-C*) since local excision of the polyp may be followed by stricture. If an early malignant change is noted in the periphery

of the polyp but the base is entirely free local excision is justifiable. If there any question about it, segmental resection should be done. To complete tl closure of the bowel the mucosa is closed separately with a continuous runnin Connell suture inverting the mucosa. (Fig. 238, B). Following this, the musc laris and serosa are approximated but not folded over with interrupted nonabsor able sutures (Fig. 238, B). The entire suture line can be reinforced by foldin over appendices epiploicae across the closure. (Fig. 238, C).

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Table 1. Colonic Polyps

Descending colon and sigmoid		72
Proximal colon		6
Transverse	4	
Splenic flexure	1	
Hepatic flexure	1	
Total		78
Postoperative deaths		2 (2.6 per cent)
1 peritonitis		
1 mesenteric thrombosis		

It is quite important to follow these patients for an indefinite period. patients who have had a polyp should be followed just as a patient is follow after resection for malignancy. Any patient who has had a polyp has a mu greater chance of having a subsequent polyp or malignancy. Subsequent s moidoscopic and roentgenographic examinations are done for the first and seco year after operation and later if symptoms recur.

Our experience at the Lahey Clinic in the removal of colonic polyps colotomy includes 78 patients (Table 1). The striking thing is the large numb occurring in the descending colon and sigmoid, with 72 found in this positic Only 6 were discovered in the right and transverse colon, including the hepa and splenic flexures; 4 were in the transverse colon while 1 each was remov from the flexures. This is in contrast to the incidence of polyps in these s ments of the bowel found by Swinton and Haug in autopsy material. In th total cases of 311, 64 were in the right colon, 85 were in the transverse col including the flexure and 162 in the descending colon and distal segment. Tl further indicates how inadequate our present methods are of diagnosis of poly in the proximal segment of the bowel. The lesions in these cases are rare discovered before malignant degeneration occurs with the production of typi symptoms of carcinoma. We are badly in need of diagnostic methods to rev polyps in this location.

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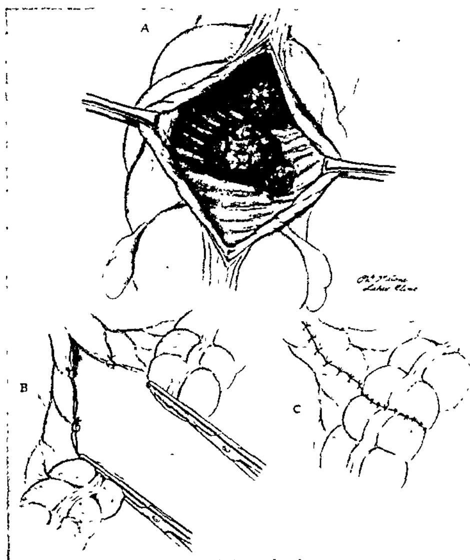


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1 peritonitis		
1 mesenteric thrombosis		

It is quite important to follow these patients for an indefinite period. All patients who have had a polyp should be followed just as a patient is followed after resection for malignancy. Any patient who has had a polyp has a much greater chance of having a subsequent polyp or malignancy. Subsequent sigmoidoscopic and roentgenographic examinations are done for the first and second year after operation and later if symptoms recur.

Our experience at the Lahey Clinic in the removal of colonic polyps by colotomy includes 78 patients (Table 1). The striking thing is the large number occurring in the descending colon and sigmoid, with 72 found in this position. Only 6 were discovered in the right and transverse colon, including the hepatic and splenic flexures, 4 were in the transverse colon while 1 each was removed from the flexures. This is in contrast to the incidence of polyps in these segments of the bowel found by Swinton and Haug in autopsy material. In their total cases of 311, 64 were in the right colon, 85 were in the transverse colon including the flexure and 162 in the descending colon and distal segment. This further indicates how inadequate our present methods are of diagnosis of polyps in the proximal segment of the bowel. The lesions in these cases are rarely discovered before malignant degeneration occurs with the production of typical symptoms of carcinoma. We are badly in need of diagnostic methods to reveal polyps in this location.

During the time that these 78 polyps have been removed exploration has been avoided many times when polyps were suspected or considered present but were ruled out by repeated examinations. Four additional patients had explorations, with negative findings even though it was believed that polyps had been demonstrated. One patient was subsequently operated upon with discovery and removal of a polyp.

There were two deaths following colotomy, a mortality of 2.6 per cent. Both of these occurred in 1941. No death has occurred since 1941.

The first patient was a man of 54 who had had blood and mucus in his stools for two months. Sigmoidoscopic examination revealed two polyps of the rectosigmoid, one of which showed signs of recent bleeding. These were destroyed by fulguration. A double contrast enema showed a polyp, 1.5 cm. in diameter, in the sigmoid. Repeat examination confirmed this finding. On April 11, 1941, the polyp was removed by colotomy and was found to have a pedicle 3 cm. in length. The base was free and frozen section was negative but subsequent permanent section showed malignant adenoma in the periphery. He developed signs of peritonitis and bronchopneumonia two days after operation. Cecostomy was performed on the fifth postoperative day but he died the following day. No autopsy was performed.

The second patient was a man of 47 years. He was first examined May 7, 1941, complaining of diarrhea and rectal bleeding of six years' duration. He had been treated for colitis. Three years previously hemorrhoidectomy had been performed without relief of symptoms. Sigmoidoscopic examination was negative. Double contrast air enema showed a polyp 3.5 cm. in diameter, with a long pedicle in the midsigmoid. The barium enema showed a large radiotranslucent area which was thought to be 5.0 cm. in diameter.

On June 4, 1941, sigmoidotomy was performed and immediate frozen section showed a mucosal polyp without evidence of malignancy but subsequent section showed a small area of adenocarcinoma. On the fourth day postoperatively he appeared to have ileus and acute dilatation of the stomach. Intubation relieved him but his symptoms recurred and he died on the eighth postoperative day. Autopsy showed a mesenteric thrombosis of the proximal jejunum with infarction, thrombosis of the portal vein and infarct of the liver and spleen. The sigmoidotomy incision was healing satisfactorily. The cause of death was mesenteric thrombosis of the jejunum. It is difficult to explain this in view of the negative heart findings unless it was caused by trauma from a retractor.

Our experience since 1940 in the treatment of intestinal polyps indicates that the number encountered is directly related to our interest in the problem and a more careful survey of patients having rectal bleeding. In Table 2 it will be seen that in the past three years the number treated has been markedly increased. In 1946, 15 polyps were operated upon, in 1947, 13 and in the first four months of 1948, 5 have been removed.

In view of our increasing experience and with technical improvements in operation, use of antibiotic drugs and the fact that no deaths have occurred in the past six years we believe that colotomy can at present be done safely. One problem relative to the treatment of colonic polyps remains unsettled. One-fourth of the patients who have had colotomy with removal of polyps have

shown early malignant changes in the periphery of
is usually not discovered at the time of operation in
only in the permanent histologic sections. During
been removed a considerable number of patients h
this diagnosis but at the time of exploration they we
cinoma and were submitted to resection. These ha
series. A decision should be reached in the light

Table 2. Colonic Polyps

Previous to	1940
	1940
	1941
	1942
	1943
	1944
	1945
	1946
	1947
(4 months)	1948
Total	

* Ten previously reported (Cattell and Swinton).

resection should be done in all patients who show
nancy. Our personal experience at this time is tha
when there is no involvement of the base results i
many of these patients may show later that resecti
taken at the initial procedure.

CONGENITAL POLYPOS

The management of congenital polyposis is a ser
are usually discovered with this disease as young

Table 3. Congenital Polyposis: Operat

Ileostomy and total colectomy ....
Ileoproctostomy and subtotal colectomy ....
One-stage ... .
Two-stage .. . .
Mikulicz ... .
Abdominoperineal resection ....
Hemicolectomy and abdominoperineal ....
Abdominoperineal ....
Total . ...

ment necessarily requires an extensive procedure w

rectal examinations when irregularity of the mucosa is noted or definite polyps are palpated. Bleeding is the most conspicuous symptom and at times massive hemorrhage occurs and may continue, jeopardizing the life of the patient. The diagnosis can be confirmed by sigmoidoscopic examination and the extent of the process and the size of the polyp can be well determined by double contrast enemas. This condition unfortunately occurs as a dominant mendelian charac-

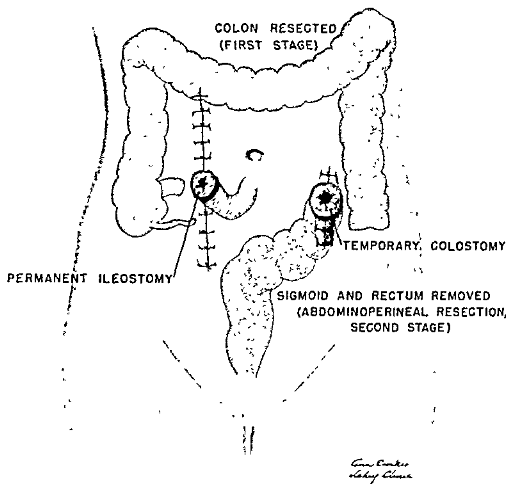


Fig. 240. Operation of choice for congenital polyposis, two-stage operation with permanent ileostomy. First stage, ileostomy established and the right, transverse and descending colon resected with implantation of the sigmoid. Second stage, resection consists of abdominoperineal removal of sigmoid and rectum.

teristic so that the majority of a family may be found to have the condition.[2,6] Fortunately, the condition is rare, occurring in our experience in approximately 0.5 per cent of patients with large intestinal lesions coming to operation.

Many operative procedures have been used in the treatment of congenital polyposis but most of them have been inadequate for the condition. The certain occurrence of malignancy in all of these patients justifies a more radical attack than has usually been adopted in the past. Colotomy with removal of multiple polyps has been employed but has no place in the present day treatment of this condition. Local or segmental resection for larger polypoid areas or in the presence of malignant degeneration has likewise been used but is unsatisfactory. Subtotal colectomy, after destruction of as many polyps as possible in the rectal

and rectosigmoid segments, has given somewhat better results but is not adaptable to most patients since the distal segment usually has the greatest involvement with polyps. *The treatment of choice is permanent ileostomy and total colectomy, including abdominoperineal resection.*

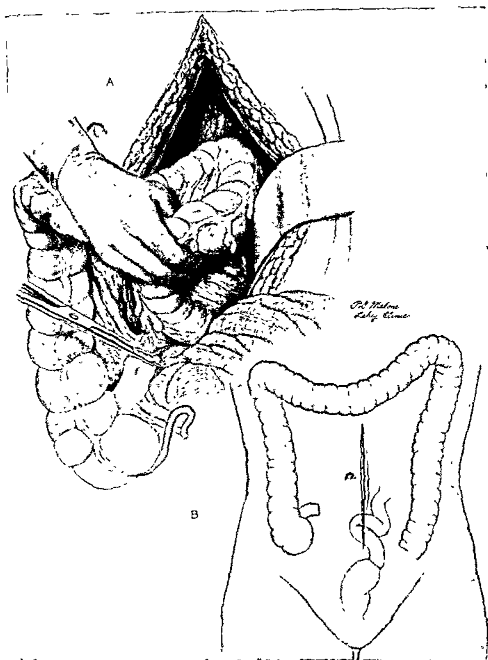


FIG. 241. Subtotal colectomy for congenital polyposis. *A*, Ileum has been divided, the right, transverse and descending colon have been freed; *B*, diagrammatic sketch showing end-to-end ileoproctostomy. The shaded portion is removed.

Our experience with congenital polyposis has not been satisfactory when subtotal colectomy has been employed although one patient has been followed twice a year for fifteen years without developing a malignancy. In view of the present day improved management of ileostomy total colectomy is justified and recommended for all patients having congenital polyposis.

In Table 3 the operative procedures which we have employed are listed. In more recent cases we are employing two-stage colectomy with ileostomy as soon as they are discovered whether malignancy has already developed or not (Fig. 240). For patients on whom subtotal colectomy has been done we have used three different types of operative procedures. In 2 patients colectomy was done in one stage with removal of the colon and end-to-end anastomosis of the ileum to the rectosigmoid (Fig. 241). In 3 the ileum was anastomosed to the rectosigmoid as the initial stage followed by subtotal colectomy (Fig. 242). In these



Fig. 242. Subtotal colectomy for congenital polyposis; a two-stage operation consisting of ileosigmoidostomy followed by colectomy. Patient followed fifteen years with repeated fulguration of polyps in the rectal segment. *A*, A full barium enema; *B*, empty film showing dilatation of the ileum.

5 patients the operative procedures were preceded by careful fulguration of the polyps in the rectal segment. In 2 patients ileostomy was performed with division of the sigmoid and implantation of the distal sigmoid. In 5 patients subtotal colectomy was done by a modified Mikulicz procedure, doing the anastomosis as low as possible. In these 5 patients fulguration of the polyps in the distal segment was performed after the operative procedure since there was diversion of the fecal stream. In patients with implantation of the sigmoid fulguration was carried out both through the proximal end and from below. In spite of careful follow-up in 1 of these patients cancer developed above the anastomosis and when the patient was submitted to resection, metastases had already occurred. Hemicolectomy and abdominoperineal resection with removal of all the colon beyond the midtransverse colon was performed in three patients and the operative procedure limited to this in view of extensive carcinoma present in the distal segment. If recurrence does not take place within a period of two years, the proximal bowel should be removed, with the performance of ileostomy. Two patients had abdominoperineal resection alone because of extensive malignancy and both subsequently died of recurrence.

In view of this discouraging experience with the so-called conservati ations of segmental or subtotal colectomy we are of the opinion that il and total colectomy should be performed in all cases.

SUMMARY

Intestinal polyps occur with sufficient frequency to constitute an ir surgical problem.

Over 50 per cent of polyps in the distal bowel can be visualized by moidoscope. Biopsy of these lesions should be used to exclude malignanc may be destroyed or removed by fulguration.

Polyps occurring in the proximal segments of the colon should be by colotomy. At the time of exploration frozen section should be dc depending upon the findings, local excision of the polyps or resectior colon performed.

Methods of localization of colonic polyps have been demonstrated technic of removal has been illustrated.

A series of 78 colonic polyps removed by colotomy are reported. The 2 operative deaths, a mortality of 2.6 per cent.

All patients who have been treated for intestinal polyps should be f carefully by repeated sigmoidoscopic and roentgenographic studies for ar nite period. They have a higher incidence of subsequent malignan normal individuals.

Surgical treatment of 23 patients with congenital polyposis is record operative procedure of choice is ileostomy and total colectomy in two st

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PRIMARY RESECTION OF THE COLON

BENTLEY P. COLCOCK

Like most surgeons interested in carcinoma of the colon we have found that an increasing number of patients with malignant disease of the large bowel can be submitted to resection and intestinal continuity immediately restored by a primary anastomosis.[1] In our hands, the percentage of two-stage operations for carcinoma of the colon has steadily decreased in recent years.

Ten years ago all patients treated in the clinic for malignant disease of the colon had a modified Mikulicz type of procedure.[3] We demonstrated to our satisfaction, at least, that this procedure was as radical in its scope as any operative procedure for carcinoma of the colon and that it was associated with a lower incidence of the most serious complication of colon resection, namely, peritonitis, than was primary anastomosis. We believe this is still true for the patient with a perforated lesion or the patient in whom distention of the bowel, excessive fat in the adjacent mesentery or a questionable blood supply to the divided end of the bowel makes satisfactory healing of the anastomosis less certain. It has long been accepted that when peritonitis does follow a primary resection and anastomosis of the colon, it is the result of contamination not by bowel content at the time of operation but usually from a leak at the suture line following the operative procedure. Excessive fat in the adjacent mesentery and epiploic appendages makes accurate serosa-to-serosa approximation difficult. If any segment of the divided margin of either limb of bowel is devitalized, necrosis and leakage from the suture line will inevitably occur. A segment of colon dilated and hypertrophied as the result of long-standing obstruction always makes primary closure more hazardous. A modified Mikulicz procedure for carcinoma of the colon can be adapted to these unfavorable cases as well as the favorable cases and in our experience can be as readily carried out on the right half of the colon (with the formation of a double-barreled Mikulicz ileocolostomy spur) as on the left colon. When a two-stage procedure is indicated, this type of operation has two definite advantages over other two-stage procedures in that the malignant lesion is eliminated at the first operative procedure and the second stage of the procedure is an extraperitoneal operation.

At the present time all patients with carcinoma of the right colon except those with complications which are known to increase the risk of primary resection of the colon are submitted to resection with primary anastomosis. The same is true to a less extent of patients with carcinoma of the left colon, namely, the distal transverse colon, splenic flexure, descending colon and sigmoid. Here the incidence of obstruction of the colon with dilatation of the proximal bowel is greater and it is often not possible to achieve satisfactory decompression of the

Revision of article originally published in Surgical Clinics of North America, 29 829–841 (June) 1949.

proximal bowel by the usual preoperative preparation. If the obstruction is complete and the distention acute, an emergency cecostomy or proximal transverse colostomy must be considered. If the obstruction is moderate or can be partially relieved by the preoperative preparation, these patients may be more safely resected by the modified Mikulicz type of procedure than by resection with primary anastomosis.

Another factor which must be kept in mind relative to patients with carcinoma of the left colon is that the lumen of the bowel is smaller on this side than it is in the right colon. The diameter of the lumen in the descending colon

Table 1. Operative Procedure. Resection for Carcinoma of Colon

	MODIFIED MIKULICZ		PRIMARY ANASTOMOSIS	
YEAR	Cases	Per cent	Cases	Per cent
1940	19	100	0	0
1945	36	80	9	20
1949	1	1.4	71	98.6

and sigmoid is the smallest of the entire colon. Obstruction at the point of anastomosis following primary resection and suture has been reported even by surgeons experienced in colon surgery and all have emphasized the danger of excessive constriction of the lumen by end-to-end suture in this segment of the large bowel. The diameter of the lumen at the point of anastomosis following the modified Mikulicz procedure is actually greater than normal and obstruction, either early or late, does not occur following this procedure.

The general trend toward the one-stage procedure has been reflected in our own experience[2] (Table 1). In 1940 all patients with cancer of the colon were

Table 2. Carcinoma of Colon

	MORTALITY	OPERABILITY
YEAR	Per cent	Per cent
1940	10.5	82.8
1945	2.4	86.5
1949	2.8	88.4

operated upon according to the modified Mikulicz type of procedure. In 1945, 80 per cent were submitted to this type of procedure and 20 per cent had resection with primary anastomosis. In 1949, 71 patients with cancer of the colon were submitted to a one-stage resection with primary anastomosis, and one patient was operated upon according to the modified Mikulicz procedure. It should be added that 4 patients who had a primary resection with anastomosis required preliminary decompression either by cecostomy or by transverse colostomy because of almost complete obstruction.

It is important to realize that this complete shift from 100 per cent two-stage procedures to almost 100 per cent one-stage procedures for carcinoma of the colon is desirable only if it can be demonstrated that it is not associated with any increase in mortality rate. The mortality rate has not increased (Table 2).

In 1940 it was 10.5, in 1945, 2.4, and in 1949, 2.8. As long as any deaths are associated with a one-stage resection, particularly if the mortality is related to intraperitoneal sepsis, the possibility must always be considered that that patient might have been saved by a two-stage operative procedure, such as the modified Mikulicz resection. In addition to the maintenance of a low mortality rate, it is important that the operability rate not be lowered. If an extensive, adherent, possibly perforated lesion cannot be resected safely with primary anastomosis, then the possibility of removing it by a two-stage procedure should be seriously considered. The operability rate in 1940 was 82.8, in 1945, 86.5, and in 1949, 88.4.

SURGICAL PRINCIPLES

Preoperative Preparation. A large share of the credit for the increased safety of the one-stage primary resection of the colon is due to an increase in the attention which is paid to the preoperative preparation of both the patient in general and his colon in particular.

Most of these patients who have had melena or a disturbance in their normal bowel function will have some degree of anemia and a decreased serum protein. In patients with carcinoma of the cecum this anemia is often severe and at times is the only symptom of the underlying disease. A low serum protein in itself can precipitate sufficient edema at the site of anastomosis to produce postoperative obstruction. Consequently, it is essential that the hemoglobin, red blood count and serum protein be restored to as near normal as possible before these patients are operated on. This can best be accomplished by transfusion of adequate amounts of whole blood. Nonprotein nitrogen and chloride levels of the blood should be checked and the electrolyte balance restored to normal. Any associated cardiovascular renal disease should be carefully evaluated and treated, if necessary. If there is a previous history of thrombosis of the deep venous system of the lower extremity, the need for prophylactic femoral ligation or the postoperative use of anticoagulant therapy should be kept in mind. Our own policy is to place these patients on a heparin-Dicumarol regimen as soon as the danger of postoperative bleeding is past, usually about the third postoperative day. (Of 10,700 operations of all types during 1947, there were but 2 postoperative deaths from pulmonary embolism.)

Before the active preparation of the bowel itself is started, these patients should be carefully examined to determine any degree of obstruction that may be present. In patients who have complete obstruction it is our policy to carry out an emergency cecostomy. A Miller-Abbott tube will decompress the small bowel but it will not relieve the closed loop of obstructed colon between a competent ileocecal valve and a constricting carcinoma of the descending colon or sigmoid. In our experience, the most efficient type of cecostomy is that in which the lateral attachments of the cecum are divided and a portion of the cecal wall itself is exteriorized through a right lower quadrant incision (Fig. 243). This type of cecostomy will adequately decompress any obstructed bowel and will remain open as long as is necessary. After the incision has been closed and the dressings applied, a large mushroom catheter is placed in the exteriorized seg-

ment of cecum by purse-string sutures. This catheter is removed in a few days and irrigation of the obstructed segment of bowel carried out. Later, following resection of the malignant growth, the cecostomy is closed by an extraperitoneal procedure.

In patients with moderate degrees of obstruction, careful examination of the abdomen, often aided by a roentgenographic film ("flat-plate"), will enable one to determine whether it is safe to give a cathartic by mouth. Unless contraindicated by obstruction, we give all patients with carcinoma of the colon 1½ ounces of magnesium sulfate by mouth and follow this with high colonic irrigations twice a day. It should be mentioned at this point that in any patient in whom an obstructing lesion of the colon is suspected, it is important to carry out the barium enema part of the gastrointestinal examination first. The admin-

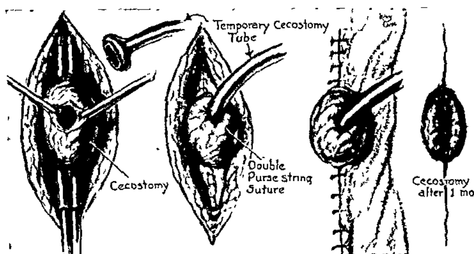


Fig. 243. The cecum has been mobilized so that it can be exteriorized without tension. The wound is closed loosely about the cecum, protected by a dressing and a de Pezzer catheter inserted. The cecostomy opening can later be closed by an extraperitoneal procedure.

istration of barium by mouth to a patient with partial obstruction may produce an acute complete obstruction.

In all patients with malignant disease of the right colon, that is, the cecum, ascending colon and proximal transverse colon, in whom the resection will be followed by an anastomosis of ileum to a distal segment of colon, a Miller-Abbott tube is inserted well down into the small bowel before they come to surgery. This is a valuable adjunct in patients of this type and permits excellent decompression of the area of anastomosis for as long as may be necessary. The Miller-Abbott tube may also be used in patients with carcinoma of the left colon but it must be remembered that in these patients, who will have an anastomosis of the left side of the colon, we cannot expect the Miller-Abbott tube to do more than counteract distention of the small bowel. In order to decompress the area of anastomosis in these patients the tube would have to pass through the ileocecal valve into the colon itself. This it will usually do if given sufficient time. However, two possible complications must be kept in mind if the tube is allowed to progress this far. In the first place, gastric dilatation may occur following operation and a second tube may have to be introduced into the stomach. In the

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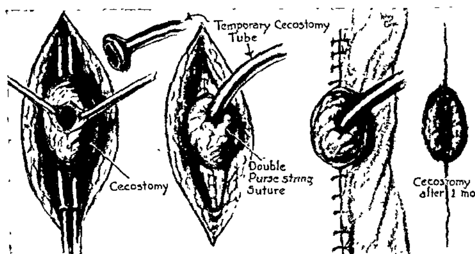


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second place, it is sometimes difficult or impossible to withdraw an intestinal tube which has passed through the ileocecal valve, particularly if mercury has been placed in the bag.

All patients who are scheduled for resection of the colon are placed on sulfathalidine for three to five days before operation. It is our practice to give 2 gm. of the drug four times a day. We feel that this has been of definite help in decreasing the risk from any contamination which may occur at the site of the open anastomosis. We also give 1 gm. of streptomycin daily for two days preceding operation. When streptomycin is used it must be remembered that its peak of effective action is limited and operation should be carried out at this time (twenty-four to forty-eight hours after administration) if the drug is to be of value.

Adequate Mobilization. Any surgeon who has had extensive experience with an exteriorization procedure for resection of the colon, such as the modified Mikulicz operation, appreciates the necessity of adequate mobilization of the colon so that the lesion may be resected widely, and the loops exteriorized without tension. It is equally important, if not more so, that sufficient mobilization be carried out before an attempt is made to approximate the two ends by intraperitoneal suture. Tension on the suture lines as the result of insufficient mobilization of the bowel will definitely increase the risk of leakage and the development of local or generalized peritonitis.

Adequate Blood Supply to the Anastomosis. The necessity of preserving adequate blood supply to the divided end of each loop of bowel forming part of the anastomosis has already been pointed out. Necrosis at the suture line has been one of the most common causes of leakage following primary suture of the large bowel. The origin and course of the main colic arteries must be kept in mind when the line of resection is determined. Because of individual variation in the size and course of the arterial blood supply to the colon it is also important to see or feel pulsating vessels supplying the divided ends of the bowel which are to be united. The bowel wall itself is supplied by long and short terminal branches of the main colic arteries. The antimesenteric border of the bowel is supplied only by the long terminal branches and is the portion of the circumference of the bowel which is most likely to be devitalized. If an attempt is made to remove epiploic appendages in order to secure more accurate apposition of the cut margin of the bowel, it should be remembered that these long terminal branches supplying the antimesenteric border often loop up into the base of these epiploic appendages as they pass around the circumference of the bowel. Dividing the bowel somewhat obliquely so as to remove more of the antimesenteric portion is an additional safeguard in securing good healing in this region. If the viability of the bowel or the integrity of the suture line is questionable a proximal transverse colostomy should be carried out. If the bowel is completely divided at this point it will defunctionalize the region of the anastomosis, and may prevent leakage and peritonitis. After sufficient time for secure healing has elapsed, the patency and integrity of the anastomosis can be demonstrated by barium enema examination and the proximal colostomy closed.

Adequate Cancer Operation. When operating upon a patient for carcinoma of the colon one must always remember that the primary purpose of the

operative procedure is to cure him of his disease, if possible. The method by which intestinal continuity is to be restored is definitely a secondary consideration and it should never be allowed to influence the extent of the resection. An adequate cancer operation includes removal of an adequate margin of normal bowel on each side of the lesion. It also implies a radical resection of the mesentery of that segment of bowel which contains the malignancy. As a rule, metastatic malignant disease first occurs in the lymph nodes of this mesentery and, in general, these lymph nodes follow the course of the major blood vessels. This means that the major blood vessels must be divided close to their origin from the superior and inferior mesenteric arteries. This wide and deep resection of the adjacent mesentery is important for a second reason. In recent years the frequency and serious prognostic significance of blood vessel invasion by malignant disease of the colon has become well known. A radical resection of the mesentery will include as extensive a removal as possible of the venous channels draining the region of the growth.

TECHNIC

Carcinoma of the Cecum, Ascending Colon, Hepatic Flexure and Proximal Half of the Transverse Colon

A careful study of resected specimens has demonstrated that malignant lesions of the hepatic flexure and proximal portion of the transverse colon frequently metastasize to the lymph nodes along the course of the ileocolic artery. For this reason radical resection of malignancy in this area should include the terminal ileum, cecum and ascending colon along with its lymphatic and venous drainage just as is carried out in patients with carcinoma of the cecum and ascending colon.

Pontocaine-glucose spinal anesthesia is used for all patients unless there is a definite contraindication. Immediately after the spinal anesthesia has been given, an intravenous infusion is started in an ankle vein and all patients receive at least 500 cc. of whole blood during the operative procedure.

A right rectus or right paramedian incision is used and it must be of sufficient length to afford good exposure of the entire right colon and terminal ileum. Before resection is started the abdominal cavity is thoroughly explored. The liver should be carefully inspected by direct vision and by palpation to rule out metastatic involvement, and the rectum and left half of the colon carefully palpated to rule out a second primary malignancy. In our experience, multiple malignancies have occurred in 4 per cent of all patients with carcinoma of the colon.

The small bowel is retracted to the left side of the abdominal cavity and, with tension on the cecum and ascending colon, the lateral peritoneal reflection is divided along the adjacent 10 to 12 inches of terminal ileum, the cecum and ascending colon and around the hepatic flexure. This dissection is extended medialward behind the mesentery of the right colon, carefully reflecting the right ureter and the retroperitoneal portions of the duodenum (Fig. 244). The right ureter can often be quickly identified by its course parallel to and just medial to the right spermatic or ovarian vessels. This entire mobilization can

usually be carried down to the root of the mesentery with the division of only a few blood vessels in the region of the hepatic flexure attachment. The importance of this initial mobilization of the right colon and its mesentery, not only to permit a sufficiently radical removal of the tumor and its mesentery but also to permit satisfactory and safe restoration of the intestinal continuity, has already been emphasized.

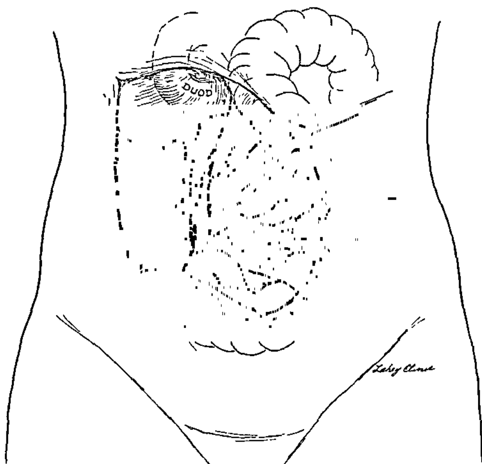


Fig 244. The peritoneum has been divided along the line of fusion of the visceral and parietal peritoneum. This will be carried around the hepatic flexure, mobilizing the proximal half of the transverse colon. The bowel is mobilized medialward. Spermatic or ovarian vessels will come into view and the ureter will be found just posterior and medial to these vessels. In the upper angle of the wound the retroperitoneal portion of the duodenum will be drawn up with the colon and must be carefully reflected posteriorly. For tumors in this location the bowel must be mobilized medialward to a point where the ileocolic, the right colic and the right branch of the middle colic arteries can be divided close to their origin.

With the mobilized colon retracted to the right, the peritoneum over the medial surface of the mesentery is then divided in a line leading from a point on the small bowel well below the lesion down to the root of the mesentery close to the origin of the ileocolic and right colic vessels and then upward to a point on the transverse colon well beyond the lesion. The blood vessels are divided along this line and the terminal ileum and transverse colon divided at the point selected.

If no contraindication to primary anastomosis is present, intestinal continuity is restored by one of three methods—an end-to-end suture of the terminal ileum

and proximal transverse colon; anastomosis of the end of the terminal ileum to the side of the transverse colon or side-to-side anastomosis between the distal ileum and proximal transverse colon. My own preference is for an end-to-end anastomosis of the terminal ileum and transverse colon because of the fact that it eliminates any blind pouch and the integrity of the anastomosis is dependent upon but one suture line. We have encountered no difficulty because of disparity in size between the lumen of the small bowel and the colon. The colon is rarely

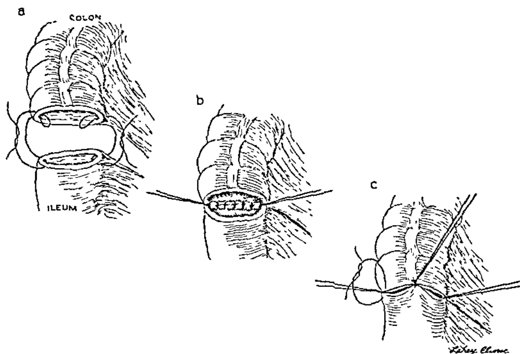


Fig. 245. *a*, If the anastomosis is being carried out without the use of crushing clamps, soiling can be guarded against by a rubber-covered clamp placed 1 to 2 inches from the cut margin of each segment of bowel. The serous and amesenteric borders are approximated by inverting Connell sutures which are cut long and serve as guide sutures.

b, The anastomosis is begun with a posterior row of accurately spaced interrupted sutures, including all coats of the bowel wall. These sutures may be silk or catgut.

c, A similar row of through-and-through sutures unites the margins of the bowel anteriorly. This first row of sutures is then reinforced by an accurately spaced row of Lembert or Cushing mattress silk sutures, uniting serosa to serosa. The guide sutures are then reversed and a second row placed posteriorly. Care must be taken not to invert too much of the bowel margin and, if a continuous suture is used for the inner suture line, a purse-string effect must be guarded against.

dilated distal to the lesion and the small bowel can be divided obliquely so that very little disparity in size will remain, and this can be taken into consideration as the sutures are placed. If an end-of-ileum to side-of-colon anastomosis is decided upon, the divided end of the transverse colon is first carefully inverted by one or two rows of catgut sutures reinforced by interrupted silk sutures. If a side-to-side anastomosis is to be carried out, the divided end of the ileum is likewise inverted. If the bowel is well prepared beforehand, we have seen no increase in morbidity or mortality by carrying out an open anastomosis rather than the so-called aseptic type of anastomosis. We feel that the open anastomosis has a definite advantage in that the sutures can be more accurately placed, and that there is less risk of overinversion of the bowel with narrowing of the lumen.

to a point on the transverse colon well proximal to the lesion. If the lesion is in the splenic flexure, the left branch of the middle colic should also be divided close to its origin from the main middle colic artery. If the lesion is in the lower descending colon, the first sigmoidal branches of the inferior mesenteric artery should be divided close to their origin. The proximal segment of transverse colon nourished by the right branch of the middle colic artery and the sigmoid colon nourished by the sigmoidal branches of the inferior mesenteric artery are then approximated by end-to-end anastomosis. The mesenteric defect is closed and the left lumbar gutter and splenic flexure regions reperitonealized. Penicillin, 100,000 units, is placed in the peritoneal cavity and the wound is closed.

Carcinoma of the Sigmoid

The lumen of the colon is smallest in the sigmoidal region and constricting lesions with obstruction are common. For these reasons a modified Mikulicz procedure should be seriously considered in any malignancy of the sigmoid associated with obstruction and hypertrophy of the proximal colon. If conditions will permit a primary end-to-end anastomosis following resection, one must be particularly careful not to overinvert the margins of the bowel at the line of suture so that early or late obstruction may occur.

A left mid rectus or paramedian incision is used. The sigmoid colon is mobilized medialward to the root of the mesentery. If the lesion is high in the sigmoid it will usually be necessary to mobilize the descending colon and splenic flexure to permit the resection of an adequate margin of bowel proximal to the lesion and the restoration of intestinal continuity without tension on the suture line. The left ureter must be visualized and preserved as this dissection is carried medialward. The sigmoidal arteries should be divided close to their origin from the inferior mesenteric artery, and the terminal branch of the inferior mesenteric, the superior hemorrhoidal artery, preserved for nourishment of the rectosigmoid.

If, because of the position of the growth, an adequate cancer operation cannot be done without division and removal of the trunk of the inferior mesenteric artery along with its terminal superior hemorrhoidal branch and accompanying lymph nodes, an abdominoperineal resection or wide anterior resection will give that patient his best chance for cure.

POSTOPERATIVE CARE

The Miller-Abbott tube in patients with carcinoma of the right colon or the Levin tube in patients with carcinoma of the left colon is placed on suction and the former is usually not removed until the patient has passed gas by rectum. During this time the electrolytic and caloric requirements are supplied by intravenous administration. The penicillin level is maintained by one injection of 300,000 units per twenty-four hours. The rectal tube is inserted at intervals to decompress the distal segment.

Leg and foot exercises to diminish venous stasis in the legs and regular, deep breathing exercises to prevent atelectasis are emphasized during the early postoperative period.

CONCLUSIONS

A one-stage resection for carcinoma of the colon with primary anastomosis with its greatly decreased hospitalization period is the procedure of choice for uncomplicated cases of malignant disease of the large bowel. With adequate preoperative preparation of the patient, accurate anastomosis, and the use of a proximal diversion colostomy or a two-stage Mikulicz type of procedure in patients with obstruction or other complication, this procedure will be associated with a mortality rate that will compare favorably with that of the more conservative types of operative procedures for resection of carcinoma of the colon.

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PROGNOSIS IN CARCINOMA OF THE COLON AND RECTUM

A 10 Year Follow-Up of 337 Patients

BENTLEY P. COLCOCK

It is a well known but occasionally forgotten fact that the term "five-year cure" is little more than a convenient yardstick when used in connection with patients suffering from malignant disease. It will give an approximate idea of the end results in a group of patients with malignant disease in one site or another, but it cannot be applied to the individual patient. Some of these people who have survived five years following the removal of their cancer will ultimately die of their original disease. This is true of carcinoma of the colon and rectum just as it is of carcinoma of the breast and other viscera. It is of interest and of value to know the results in these patients with carcinoma of the colon and rectum five years after operation and what the chances are for an individual patient with a malignant lesion to live, not only five years, but ten or more years following resection of the malignant tumor.

In 1929, Jones reported a 22.7 per cent mortality in a series of 204 cases of carcinoma of the rectum in which the patients were treated by abdominoperineal resection. Seventy per cent of the patients who survived operation were alive and well at the end of three years and 50 per cent were living five years after their operation. His operability or resectability rate was 53 per cent.

Miles, in 1931, followed a group of 94 patients who had survived abdominoperineal resection for carcinoma of the rectum, and found 69 alive and well at the end of five years. This is a five-year nonrecurrence rate of 73.3 per cent.

Abel, in 1935, found a 69.2 per cent survival rate in 150 patients whose course was followed for five years after abdominoperineal resection for carcinoma of the rectum. These figures are somewhat higher than those found in this country.

In 1933, Rankin, in a follow-up of 300 patients who had had resection for carcinoma of the rectum, found a five-year survival rate of 48 per cent in those patients who showed no metastasis to lymph nodes in the resected specimen. In the group of patients in whom the lymph nodes were involved, 20 per cent survived five years. In 187 cases of carcinoma of the right colon, Rankin and Olson obtained five-year "cures" in 39 per cent of their patients with nodal involvement, and in 66 per cent of those without nodal involvement. In 266 cases of carcinoma of the left colon, their figures were 29 per cent and 56 per cent, respectively.

In 1943, Cattell found 53.6 per cent of 140 patients who had survived resec-

Revision of article originally published in Surgery, Gynecology and Obstetrics, 85.8–13 (July) 1947.

tion for carcinoma of the colon or rectum were living five ye
operation. This figure was based on all patients submitted
included palliative operations and unfavorable resections as
cases. It is of great value to know the operability or resectabilit
ing statistics relating to end results, for in any group of case
with unfavorable lesions are not submitted to resection, the s
rally will be higher. The operability rate in this group of pati
cent.

In 1943, Mayo and Twyman followed 79 cases of carcinor
and found that 70.9 per cent of the patients with favorable les
cent of those with unfavorable lesions were alive and well
operation. In 1945 Hayden, in reviewing 198 patients with
rectum who were submitted to resection, found a five-year
per cent among the 98 patients whose course was followed for f
His resectability rate was 80.6 per cent for all patients seen
for the group who came to operation.

The spread of carcinoma of the colon or rectum through t
phatics has long been understood. For many years we have
and examined the mesenteric lymph nodes in each resected
presence of metastatic carcinoma. The significance of nodal in
prognosis in the individual case is apparent from the present
the cases reported in the literature. Only in recent years, h
frequency with which carcinoma of the colon and rectum ma
the vascular system been fully appreciated. Any discussion of
ing resection for carcinoma of the colon and rectum shoul
seriousness of blood vessel invasion as seen in the microscopi
the resected specimen. In one study of 208 patients we foun
patients who had shown blood vessel invasion at the time o
15 per cent were alive five years later.

In the present study, the case histories of 337 patients with
colon and rectum were carefully reviewed. All were treated p
307 of these patients have been followed for at least ten years.

The patients were divided into two main groups. In the first
with carcinoma of the colon, including carcinoma of the c
transverse, descending, and upper sigmoid colon. The second
of patients with carcinoma of the lower sigmoid, rectosigmoid
the second group some type of resection of the rectum and re
the establishment of a proximal colostomy, was carried out.

CARCINOMA OF THE COLON

There were 103 patients with carcinoma of the colon. The
was 27 years of age, the oldest 74, and the average age wa
incidence of carcinoma of the colon was slightly higher in w

Of the 27 patients in whom the malignant disease had extended to the adjacent lymph nodes or involved the surrounding structures, 8 died in the hospital and 15 died of recurrence of their disease within five years (Table 1). One patient died of a recurrent carcinoma after having survived five years and 3 patients are living and well ten or more years after operation. Thus, for this unfavorable group, the five-year survival rate has dropped to 21 per cent and the ten-year survival rate to 15.7 per cent. One patient with sarcoma of the colon died less than eighteen months after operation from recurrence of his malignant disease. Four patients in whom resection was done in the presence of liver metastases lived from one to five years following operation. In the one case in which the patient survived more than three years, there is some question as to whether the nodules noted in the liver at the time of operation were actually metastases, since no biopsy specimen was obtained. Of the 4 cases in which laparotomy only was performed, not 1 patient survived a year. The same was true for the 13 patients in whom only a sidetracking anastomosis was carried out.

CARCINOMA OF THE RECTUM AND RECTOSIGMOID

There were 234 patients with carcinoma of the rectum and rectosigmoid. Of these, 129 were males and 105 were females. Their ages ranged from 21 to 75 years, with an average age of 57 years. It is worth while to note again that carcinoma of the rectum is found not uncommonly in patients under the so-called "cancer age." Nineteen patients, or 8 per cent of the entire group, were under 40 years of age.

Procedure. One hundred forty-six patients, or 62 per cent of this group, were submitted to some type of resection. A two-stage Lahey procedure was performed in 83 or 56.8 per cent of the 146 patients, a one-stage abdominoperineal (Miles) resection in 24, or 16.4 per cent, a posterior resection in 22 or 15 per cent, and an anterior resection (with permanent colostomy) in 17 or 11.6 per cent. Eighteen of these resections were considered palliative, 11 definitely so because of the presence of liver metastases and 7 probably so because of invasion of adjacent structures. A steady tendency toward the increasing use of the one-stage Miles abdominoperineal resection is shown by the fact that this procedure was used in 16.4 per cent of the above group, 76.7 per cent in the year 1941, and 97.5 per cent in 1945. Resection was not carried out in 88 cases, a colostomy having been done in 62, a first-stage Lahey procedure in 10, and a laparotomy only in 11. No operation was performed in 5 cases.

Mortality. Of the 146 patients who were submitted to resection, including 18 palliative resections, there were 11 deaths, or a mortality for the resected cases of 7.5 per cent. Since 1936 the operative mortality for carcinoma of the rectum has dropped to 3.8 per cent in 1941 and 6.2 per cent in 1945. At the same time the operability rate has increased from 62 per cent to 83 per cent.

Twenty-eight deaths occurred in the group of patients whose growths were so extensive that only laparotomy or colostomy was possible.

Follow-up (Table 2). In the group of 73 patients in whom there was no *evidence of involvement of the liver or lymph nodes at the time of resection*, 31 patients are known to be living and well ten or more years following their operation. At the end of five years following operation 36 patients were living and well

without evidence of recurrence. Five patients died from recurrence of the carcinoma between their fifth and tenth postoperative years. Twenty-four patients died from recurrent carcinoma in from one month to five years following operation. Seven patients subsequently died from other causes, with no evidence of recurrence at the time of their death (5 of these 7 patients had survived without recurrence four and one-half to seven years after their resection). There were 6 postoperative or hospital deaths. The 1 patient with sarcoma of the rectum died from recurrent malignant disease less than eighteen months after his operation. Omitting the 6 postoperative deaths and the 7 patients who died from causes other than the recurrence of their carcinoma, the five-year survival rate is 60 per cent and the ten-year survival rate is 51.6 per cent.

In 52 cases no metastases were noted in the liver at operation, but the carcinoma was found to have spread to the mesenteric lymph nodes on examination of the resected specimen. Of this group, 10 patients are living and well ten or more years following their operation. Three patients died from a recurrence of their malignant disease between their fifth and their tenth postoperative years. There were 5 postoperative deaths and 4 other patients subsequently died from other causes, with no evidence of recurrence at the time of their death. Omitting the postoperative deaths and the patients who died from causes other than malignant disease, the five-year survival rate is 30.2 per cent and the ten-year survival rate is 23.2 per cent.

In the entire group, 28 patients died of their disease within six months of operation. Of these, 25 or over 89 per cent, occurred in the group in whom only laparotomy or colostomy was possible. Thirty patients died of their disease in six to twelve months after operation. In 16, or 53.3 per cent, resection was not possible, and in an additional 16.6 per cent liver metastases had been noted at the time of the palliative resection. Although there was no difference in the length of survival of patients who had resection of their growth in the presence of liver metastases and those who had colostomy only (only 1 patient in each group lived more than three years), there was a marked difference in the postoperative clinical course. Those patients, in whom the rectal lesion was left in situ were very uncomfortable from the constant discharge of mucus and blood from the rectum and they often had severe pain from sciatic and perineal nerve involvement. Those patients in whom the primary growth was removed were usually comfortable until within a few weeks of their death.

Of the 15 patients in whom the ten-year follow-up was incomplete and who were not included in the above analysis, 6 patients had had such advanced disease that only a laparotomy or colostomy was possible at the time of operation. Three other patients had resection in the presence of metastases to adjacent lymph nodes or local extension of the growth.

Thus, of the resected cases not known definitely to be palliative or unfavorable, only 6 were not followed for ten years and 5 of these are known to have been living without recurrence six to eight years after operation.

SUMMARY

The case histories of 81 patients who had resection for carcinoma of the colon ten or more years ago were carefully reviewed. Of the patients with favorable

lesions, that is, those in whom the adjacent lymph nodes were not involved and there was no local invasion of the surrounding tissues, 64.3 per cent survived five years without recurrence and 57.1 per cent are living and well without recurrence ten or more years following resection of their malignant tumor.

Of the patients with unfavorable lesions, that is, those in whom the lymph nodes showed evidence of metastases or there was invasion of the surrounding structures by the tumor, 15 per cent were living and well five years after operation. Eleven per cent are living and well ten or more years following resection (Table 3).

Table 3. Carcinoma of Colon

GROUP	PERCENTAGE OF PATIENTS LIVING AND WELL FOR 5 YEARS	PERCENTAGE OF PATIENTS LIVING AND WELL FOR 10 YEARS
Unfavorable (lymph nodes involved and local invasion)	21.0	15.7
Favorable (lymph nodes not involved)	64.3	57.1

The histories of 146 patients who had had a radical resection for carcinoma of the rectum or rectosigmoid ten or more years ago were also reviewed.

In the favorable group (adjacent lymph nodes negative for carcinoma, no local invasion) 60 per cent were found to be well without recurrence at the end of five years; at the end of ten years this figure had dropped to 51.8 per cent.

In the less favorable group (lymph nodes showing metastatic carcinoma or invasion of the surrounding tissues by carcinoma), 30.2 per cent survived five years without a recurrence. Only 23.2 per cent are living and well ten or more years following their operation (Table 4).

Table 4. Carcinoma of Rectum and Rectosigmoid

GROUP	PERCENTAGE OF PATIENTS LIVING AND WELL FOR 5 YEARS	PERCENTAGE OF PATIENTS LIVING AND WELL FOR 10 YEARS
Unfavorable (lymph nodes involved and local invasion)	30.2	23.2
Favorable (lymph nodes not involved)	60.0	51.8

Of the patients who died from malignant disease between the fifth and tenth postoperative years, the majority died between five and one-half and six and one-half years following operation. Two patients lived seven years and one eight years. All of these patients gradually failed and died with the signs and symptoms of carcinomatosis of the abdominal cavity. Nevertheless, the possibility exists that some in this group may have succumbed to a second, undetected primary lesion arising in the gastrointestinal tract and not as the result of a recurrence of their resected lesion.

CONCLUSIONS

These figures suggest that in a patient with carcinoma of the rectum, in whom the mesenteric lymph nodes of the resected specimens show no evidence of car-

cinoma, the prognosis is approximately twice as favorable as it is for a patient in whom the lymph nodes are positive. The unfavorable significance of positive lymph nodes in carcinoma of the colon appears even greater.

The figures also suggest that, although some patients who are living five years after resection for carcinoma of the colon or rectum will ultimately die of their disease, the five-year survival rate very closely approximates the curability rate provided a second malignant lesion does not develop.

It is also probably true that a patient operated on for carcinoma of the colon or rectum, in whom the lymph nodes in the resected specimen are negative, has better than a 50 per cent chance for a permanent cure.

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THE SURGICAL TREATMENT OF DIVERTICULITIS AND ITS COMPLICATIONS

CORNELIUS E. SEDGWICK

Diverticula of the large bowel are outpouchings or herniations of the mucous membrane through the muscularis. They occur near the taenia where the blood vessels enter the gut. Diverticula may occur in any segment of bowel but are most prevalent in the descending colon and sigmoid. Multiple diverticula known as diverticulosis are usually found in the fourth, fifth and sixth decades of life, are more common in males than in females and produce few symptoms.

As pointed out by Spriggs,[1] there are three main stages in the development and progress of diverticulitis: first, the prediverticular stage characterized roentgenologically by loss of normal bowel segmentation, second, the formation of definite diverticula (diverticulosis) and third, the stage of inflamed diverticula or diverticulitis. The third stage is secondary to inspissated, trapped fecal material within the sac or diverticula with associated strangulation and inflammation. The diagnosis and treatment of diverticulitis is mainly a medical or gastrointestinal problem. On occasion, however, certain complications, namely obstruction, perforation and fistula formation, occur which require surgical intervention.

OBSTRUCTION

Intestinal obstruction may occur secondary to acute or chronic diverticulitis. In acute diverticulitis there is edema and swelling of the mucosa which produces partial obstruction. This type of obstruction usually subsides with conservative therapy and rarely becomes a surgical problem. On the other hand, chronic diverticulitis may produce chronic inflammatory changes and fibrosis of the bowel wall causing almost complete stenosis which necessitates surgical intervention. A patient with such lesions has typical clinical findings suggestive of intermittent partial obstruction of the large bowel. A barium enema will confirm the diagnosis. Although the diagnosis of an obstructive lesion of the colon is obvious, the determination of the nature of the lesion presents a difficult problem. Is the obstructive lesion a malignancy or secondary to diverticulitis? It is of utmost importance to make this differential diagnosis correctly so that the proper surgical procedure may be instituted. It is to be remembered that it may be just as difficult to determine the disease at the time of laparotomy as before opening the abdomen. Therefore, the history, clinical findings and roentgenologic studies must be carefully evaluated to arrive at the correct preoperative diagnosis.

Several clinical aspects of diverticulitis help to distinguish this disease from carcinoma of the colon. The patient with chronic diverticulitis usually has been ill longer than the patient with carcinoma of the colon. The symptoms may be vague, such as flatulence, change of bowel habits, diarrhea or constipation. They

Originally published in Surgical Clinics of North America, 31 783–788 (June) 1951.

may progress to symptoms of intermittent partial obstruction which may lead, on occasion, to complete obstruction. Obstruction may develop more rapidly after the onset of symptoms in the patient with colonic malignant disease than in the patient with chronic diverticulitis. Yet in spite of the chronicity of diverticulitis, the general condition of a patient with this disease is better than that of the patient with carcinoma; there is less weakness and debility.

It is frequently stated that patients with diverticulitis rarely pass gross blood by rectum and that patients with colonic carcinoma frequently do. This is true and of diagnostic value, but it must be emphasized that patients with diverticulitis do occasionally pass bright red blood in the feces.

Patients with chronic diverticulitis may have episodes of active inflammation which produce symptoms of peritoneal irritation such as localized pain, tenderness and spasm. There may be a tender mass in the left lower quadrant of the abdomen. Such peritoneal irritation is frequently associated with fever and leukocytosis. These findings are unusual with malignant disease of the colon.

Sigmoidoscopic examination rarely reveals the presence of diverticulitis but it is of real importance in ruling out a malignant lesion of the sigmoid and rectosigmoid.

The most important study to distinguish diverticulitis from colonic carcinoma is by roentgenologic examination after a barium enema and after the air double contrast enema. The characteristic finding in diverticulitis is a long filling defect with narrowing. Usually other diverticula are present in other segments of the bowel. The mucosa is intact. The area involved is rigid and tender. This is in contrast to the short, circumscribed, nontender filling defect with loss of the mucosal pattern of typical carcinoma. In spite of careful clinical and roentgenographic studies, on occasion it may be impossible to distinguish carcinoma of the colon from diverticulitis and in such cases the lesion must be considered to be malignant.

Surgical Management. Partial bowel obstruction secondary to chronic diverticulitis becomes a surgical problem if the obstruction becomes complete, if obstruction is recurrent and does not respond to adequate medical management and if the lesion cannot be distinguished from carcinoma. The surgical procedure of choice in a given case depends upon the state of the bowel and the lesion at the time of operation. In general, there are three surgical methods: (1) primary resection, (2) the Mikulicz extraperitoneal type of resection and (3) a three-stage procedure involving a preliminary diversional colostomy followed by primary resection and closure of the colostomy.

Primary resection with an end-to-end anastomosis is reserved for a relatively small group of selected cases. The disease must be in a quiescent state. The bowel must be well prepared with intestinal antiseptics and decompressed thoroughly with a Miller-Abbott tube. The resection must be wide of all possible disease. It must be remembered that the extent of the involved bowel is difficult to determine grossly and that anastomosing diseased bowel may end in leakage and fistula formation which plague bowel resections for diverticulitis in ill-chosen cases. In properly selected cases, however, this method gives the most gratifying results with the least period of hospitalization and discomfort to the patient.

The Mikulicz type resection is reserved for those cases of chronic diverticulitis

in which there is evidence of recent inflammation which prohibits primary anastomosis, but in which it is technically possible to exteriorize the involved bowel without difficulty. Frequently, however, diverticulitis involves the mesentery and there is considerable shortening of the mesentery, making it almost impossible to exteriorize the lesion adequately with sufficient bowel for a satisfactory Mikulicz resection.

The third and most frequently used surgical method of handling partial obstruction caused by chronic diverticulitis is a three-stage procedure. This method is elected in those cases in which there is active inflammation or peridiverticulitis, in which the bowel is not properly decompressed and prepared or the limits of the inflammation are too widespread. If the case is borderline and it is difficult to choose between a one- or three-stage procedure, it is wiser to choose the staged method. The three-stage method consists of a diversional colostomy followed by resection at least three months after the first procedure, and shortly thereafter by closure of the colostomy. At the clinic the Mikulicz type of transverse colostomy is preferred for the first stage. This type of colostomy completely diverts the fecal stream and it is easy to close extraperitoneally. It cannot be emphasized too strongly that the second stage, that of resection, should not be performed too soon after the diversional colostomy. This mistake is frequently made and leads to fistula formation. The bowel should be put at rest for at least three months and frequently for six months or longer. This method should be used most often and will be followed by the fewest complications.

PERFORATION

Perforation of the colon associated with acute diverticulitis results in diffuse spreading peritonitis or the formation of a localized abscess. Perforation may occur suddenly with little warning or it may follow an attack of acute diverticulitis. Perforation with peritonitis produces the clinical picture of an acute abdominal condition, pain, tenderness, spasm, fever and leukocytosis. With abscess formation the tenderness is localized in the left lower quadrant. Occasionally the diseased bowel may be in a long loop of sigmoid which may rest to the right of the midline, and the symptoms simulate those of acute appendicitis. The diagnosis of an acute abdominal condition requiring surgical exploration is made without difficulty, although the exact etiology may be obscure until the abdomen is open.

Surgical Management. Patients with this complication require thorough antibiotic therapy and careful preoperative and postoperative supportive treatment. The type of surgical procedure for diverticulitis with perforation varies according to the condition of the patient and the gross pathologic condition found at the time of laparotomy. In general, there are three methods of handling diverticulitis with perforation.

The involved bowel with the perforation may be exteriorized and resected in the Mikulicz fashion. If there is difficulty in mobilizing the lesion, and there frequently is, and if tissue planes must be entered in the presence of infection, this method must be abandoned for the third method. In selected cases, however, exteriorization of the lesion with the perforation is justified.

A second method of managing perforation of the bowel secondary to divertic-

ulitis is to do nothing but institute adequate drainage. This is the method of choice in critically ill patients or those who are very poor surgical risks, especially those with a localized abscess. If the patient survives, a fecal fistula is present, but this can be dealt with satisfactorily at a later date.

The third method of managing this type of perforation is the best and most frequently used. An attempt is made to close the perforation with omentum or epiploic appendage, the region involved is drained and the fecal stream is diverted by means of a transverse colostomy. We prefer a Mikulicz type of colostomy if this can be done without too much dissection and mobilization; otherwise a simple loop colostomy will suffice. This method puts the involved area of bowel at rest, allows adequate drainage and produces optimal conditions for healing. Futhermore, the diseased segment of bowel can be prepared for resection at a later date.

FISTULA FORMATION

Because of the close apposition of the sigmoid and bladder it is not surprising that an inflamed segment of lower colon occasionally perforates into the bladder with the formation of a vesicosigmoid fistula. This complication occurs less frequently in females probably because the uterus acts as a barrier between the bowel and urinary bladder. As expected, patients suffering from this complication of diverticulitis have symptoms and findings referable to both the urinary and gastrointestinal tracts, although the urinary symptoms are considerably more pronounced.

The onset of the formation of a vesicosigmoidal fistula is preceded by lower abdominal pain and tenderness and is associated with fever. These symptoms are followed by pain and frequency of urination. The urine becomes cloudy and thick and occasionally contains blood. Air and fecal material may be passed with the urine. Chills and fever develop characteristic of urinary tract infection. Frequently the toxicity of this infection subsides and the patient may return almost to normal health except for persistent pneumaturia and mild urinary symptoms. Occasionally patients remain in this state for months or even years before obtaining surgical treatment. A history of abdominal pain followed by urinary infection and pneumaturia is diagnostic of vesicosigmoidal fistula.

Before surgical intervention is contemplated sigmoidoscopy, barium enema and cystoscopic studies are performed. The sigmoidoscopy may not reveal the presence of diverticulitis and rarely will the orifice of the fistula be seen. This examination, however, will help to rule out the presence of a colonic malignant lesion. Barium enema will reveal the presence of diverticulitis and frequently the fistula can be visualized as the barium passes from the colon into the bladder. By cystoscopic examination the actual opening of the fistula in the bladder can frequently be visualized, and in those cases in which the fistula cannot be seen, certain changes of the bladder may be noted which are characteristic of fistula formation. Furthermore, a cystogram may show dye escaping from the bladder through the fistula into the colon.

Surgical Management. Patients submitted to operation for excision of a vesicosigmoidal fistula are carefully prepared with intestinal and urinary antiseptics, and adequate supportive therapy is given. The surgical treatment of a vesicosigmoidal fistula secondary to diverticulitis is always a staged procedure

consisting of a preliminary diversional transverse colostomy, resection of the fistula and diseased bowel and finally closure of the colostomy. It is foolhardy and will lead to disaster to attempt primary closure of the fistula and resection of the involved bowel in one stage. Furthermore, it must be emphasized that even following a preliminary colostomy sufficient time must be allowed for the urinary tract to be restored to normal and the gastrointestinal tract to be thoroughly decompressed and cleaned of all fecal material and infection. This may require three to six months. The second stage consists of excising the fistulous tract from the bladder and repairing the opening in the bladder. This stage is accompanied by an anterior resection of the involved bowel with primary anastomosis. The final stage is closure of the colostomy which again must be performed only after a waiting period of several weeks.

SUMMARY

Diverticulitis is usually a medical problem. Certain complications, namely obstruction, perforation and fistula formation, may occur requiring surgical intervention. The important diagnostic differentiation of this disease from carcinoma of the bowel is emphasized. Once the possibility of malignant disease is eliminated, the proper surgical procedure can be instituted. There are several surgical methods of handling these serious complications. The method elected depends upon the condition of the patient, the lesion and the condition of the adjacent bowel and surrounding structures at the time of operation. In general, it should be emphasized that whereas the surgical aim in malignant disease of the colon is early resection, the surgical procedure of choice in most cases of diverticulitis is delayed resection preceded several weeks or even months by a diversional colostomy.

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ABDOMINOPERINEAL RESECTION FOR CARCINOMA OF THE RECTUM

RICHARD B. CATTELL

The combined abdominoperineal removal for carcinoma of the rectum was introduced by Miles approximately forty years ago. The procedure was based on careful studies of the pathways of spread of the malignant lesion from its primary site. The operation has been widely accepted and must be considered as the most radical procedure and offering the greatest chance for cure for this lesion. Later studies of the vascular and lymphatic spread as well as contiguous invasion by Gilchrist and David, Coller, Morgan and others have further proved the soundness of the operation. With an increasing experience in carrying out the procedure of abdominoperineal resection certain technical advances have been made to increase its scope and facilitate its completion.

The chief differences in the modern abdominoperineal resection, taking advantage of technical improvements, are as follows: (1) the operation is now applied to a very high percentage of all patients with this lesion and a more radical removal is probably done, (2) a more complete pelvic dissection is done during the abdominal part of the operation with division of the attachments to the level of the levator ani muscles, (3) a more satisfactory reconstruction of the pelvic peritoneal floor is accomplished and (4) the perineal part of the operation has been simplified and a posterior pack avoided.

One-stage abdominoperineal resection is employed at the Lahey Clinic with rare exceptions for all malignant lesions in the low sigmoid, rectosigmoid and rectum. A technic for the operation will be described which permits completion of the procedure within a reasonable time. A definite order of steps will be listed which may be modified, depending upon the extent of the lesion or other findings. With our experience with this procedure we have not considered it advisable or necessary to employ the synchronous combined abdominoperineal resection with the utilization of two operative teams.

During the past five years over 90 per cent of all patients having carcinoma of the rectum have been submitted to abdominoperineal resection. Thus the procedure has been utilized in both favorable and unfavorable cases, including those with liver metastases, since the lesion [illegible] the patients in who [illegible] no longer has an important place in the management of this condition. There are few lesions that cannot be removed because of local extension or invasion. The chief contraindication to resection today is marked extension in the pelvis in the presence of massive liver metastases, a situation in which a short life expectancy exists. Posterior or perineal excision of the rectum for carcinoma

Originally published in Surgical Clinics of North America, 31:757–773 (June) 1951.

has been limited to 2 cases in the last five years. Occasionally anterior resection with anastomosis has been performed when the primary lesion is small yet liver metastases are present.

In increasing the number of patients submitted to resection it has been found necessary to increase the scope of the operation. Total hysterectomy and removal of the posterior vaginal wall are frequently carried out when the lesion is extensive and infiltrative in the pelvis. Removal of portions of the bladder including the sacrifice of one ureter may be necessary. Most importantly, if metastatic nodes are found along the inferior mesenteric vessels and in the retroperitoneal region, hemicolectomy with removal of all of the inferior mesenteric artery and vein and the entire mesentery of the left colon should be carried out.

ANESTHESIA

Spinal anesthesia is used routinely. Gas-oxygen-ether, administered through an endotracheal tube supplemented by a curare preparation, is occasionally used when there is a contraindication to spinal anesthesia. Pontocaine weighted with glucose, administered by the fractional or continuous method by the technic of Lemmon or Saklad, is preferred, supplemented by light cyclopropane anesthesia. Intravenous fluid and blood are given as indicated during the course of the operative procedure. Spinal anesthesia offers the best relaxation of the abdominal wall and furthermore causes contraction of the small intestine so that the pelvic exposure is quite adequate when the patient is placed in the Trendelenburg position. This type of anesthesia is particularly useful when left hemicolectomy is combined with abdominoperineal resection. When experienced physician-anesthetists are available, the operative risk from the use of spinal anesthesia is not considered to be increased.

TECHNIC OF OPERATION

Abdominal Portion

Incision. A left rectus incision splitting the fibers of the lateral third of the rectus muscle is preferred (Fig. 247). It offers the best vision to the surgeon on the left side of the table and provides the best mechanical advantages. It permits easy dissection of the lateral attachments of the sigmoid and descending colon as well as accurate approximation of the colostomy loop to the lateral wall, closing the left lumbar gutter. Furthermore, should the findings indicate the necessity for removal of all of the left colon an extension of this incision upward readily permits freeing of the splenic flexure and left half of the transverse colon. The left rectus incision has two definite disadvantages: (1) a weaker wall, resulting in an occasional incisional hernia about the colostomy and (2) it brings the colostomy out through the original incision. The latter we do not consider a material disadvantage. In the ordinary case, adequate exposure can be procured without extending the incision above the level of the umbilicus and if the incision is limited to this level the wall is not appreciably weakened. The individual surgeon may choose a midline or a paramedian incision on either side with a midline colostomy or one brought out through a muscle-splitting incision above the left iliac crest.

Exploration. The statement that routine exploration of the abdomen should be carried out may seem unnecessary, but more than a casual exploration is mandatory. A definite order of palpation should be followed. All of the palpable surfaces of the liver should be carefully searched but it must be appreciated that many small benign nodules, both cystic and neoplastic, may be encountered. It may be advisable to biopsy or visualize doubtful nodules in order to arrive at a proper prognosis. The determination of the presence of gallstones may be important because acute cholecystitis as a complication during the immediate postoperative period may occur. The fact that, in 4 per cent of patients, a second primary malignant growth is present makes careful palpation of all of the large

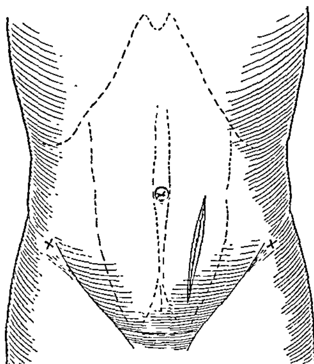


Fig 247. A lower left rectus incision is made, splitting the muscle fibers.

intestine important. We have, on two occasions, found three primary lesions by this means. A low attachment of the terminal ileal mesentery should be noted since, if present, it should be freed so that the ileum will not be drawn into the pelvis by reconstruction of the pelvic peritoneal floor. In spite of careful palpation of the colon, small polyps will not be felt but larger polypoid lesions may be encountered. The presence of diverticula in the descending colon above the point of proposed resection likewise should be noted since, under these circumstances, immediate decompression of the colostomy is advisable. Nodes along the inferior mesenteric vessels must be palpated and the scope of the procedure planned from such findings. The extent of the lesion in the pelvis is determined and particularly whether there has been a serosal break or whether local fixation or invasion exists. If the lesion is thought to be penetrating or folded over on itself, one must be guided in the subsequent steps of the operation by this finding in order to avoid rupture of the lesion with contamination in the pelvis and possible implantation of malignant cells. From the exploratory findings the extent of the procedure with the limits of the resection can be carefully planned.

The Sigmoid Colon. The lateral peritoneal attachments of the descending colon and sigmoid are severed 1 or 2 cm. away from the bowel (Fig. 248). This is continued downward, retracting the sigmoid to the right until all of the attachments to the brim of the pelvis are severed and the left mesocolon is freed up to the median line. At this stage three structures lie in close proximity and parallel to each other on the left posterior wall. On the left are the ovarian or spermatic vessels, in the middle is the left ureter and adjacent to it are the superior hemor-

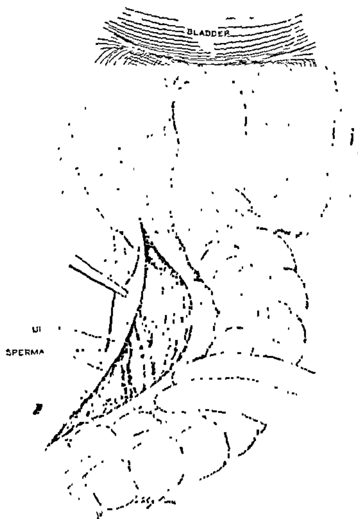


Fig. 248. The sigmoid is displaced to the right and the lateral peritoneal attachments are divided. The spermatic or ovarian veins and the left ureter are identified. A small leaf of peritoneum is left attached to the descending colon.

rhoidal vessels (Fig. 248). The latter two structures must be widely separated and the ureter and genital vessels retracted to the left. In obtaining adequate freedom of the mesocolon it is necessary to identify and sever the pericolic fascia or fascia propria which permits the widest extension of the mesocolon. With elevation of the sigmoid the left colic and sigmoidal vessels are identified (Fig. 249) by palpation or transillumination and a point selected for division of the mesocolon which will permit adequate resection of the mesentery, yet leave sufficient bowel so that it can be brought out easily as a permanent colostomy (Fig. 249). Usually, the left colic artery is preserved but the sigmoidal vessels are

sacrificed. Before elevation and division of the inferior mesenteric artery below the left colic artery, the ureter must again be visualized and retracted before raising the vessel pedicle. There is no danger to the right ureter in this maneuver. Division of the vessels is usually carried out above the level of the bifurcation of the aorta. Following division and ligation of the vessel pedicle, further traction is avoided on the portion of the bowel to serve as the colostomy.

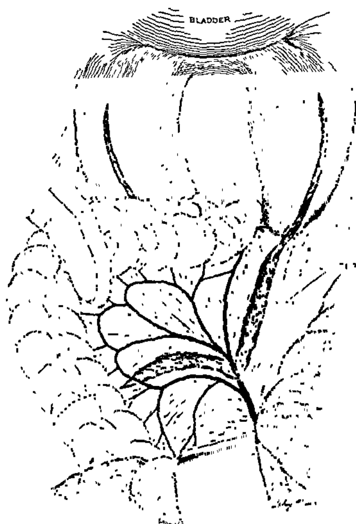


Fig. 249. Identification of vessels in the mesosigmoid is indicated. The usual point of division of the inferior mesenteric artery is distal to the left colic artery. The site on the descending colon for the permanent colostomy is shown by the dotted line.

Pelvic Dissection. The lateral pelvic peritoneum is next incised along the course of the ureters (Fig. 250) down to the uterosacral ligaments in the female and the seminal vesicles in the male. The lower bowel and its severed mesentery are drawn forward and the hypogastric nerve and its presacral components (Fig. 250) are identified and divided to permit entry into the pelvic space between the iliac vessels. This posterior pelvic dissection should be begun with sharp dissection to avoid injury of the veins in the hollow of the sacrum and the posterior dissection can then be carried out bluntly down to the level of the coccyx (Fig. 251). At this time the anterior peritoneal division is carried out; in the male the incision is made well up on the posterior wall of the bladder and in the

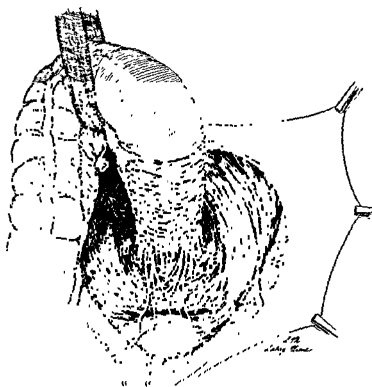


Fig. 250. Gauze traction on the distal bowel is maintained to facilitate the posterior pelvic dissection. The hypogastric plexus and presacral nerve components are shown. Both ureters lie at the limits of the lateral dissection.

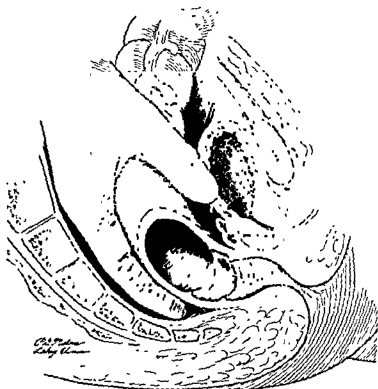


Fig. 251. The blunt dissection of the posterior space is indicated, carrying it down to the tip of the coccyx.

female across the uterosacral ligaments. The anterior dissection is then done bluntly by elevation of the cervix and vagina and this is extended well down to the level of the levators. In the male a similar dissection frees the seminal vesicles and displaces them anteriorly.

In proceeding with the lateral dissection both ureters must be visualized. The presacral fascia is cut and pushed forward, and the dissection carried up to the middle hemorrhoidal vessels or lateral rectal stalks. These are identified and clamped (Fig. 252) as far laterally as possible, following which they are divided and ligated.

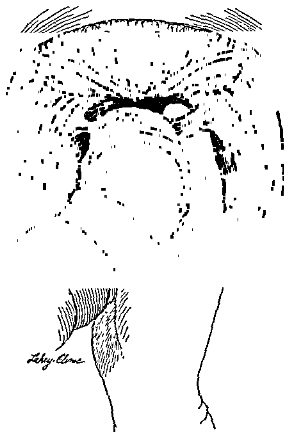


Fig. 252. The middle hemorrhoidal vessels are identified, then clamped, divided and ligated on the lateral pelvic wall.

In the male patient the seminal vesicles are displaced anteriorly and Denonvilliers' fascia identified and incised (Fig. 253), following which the posterior surface of the prostate can be completely freed. At this level the second component of the middle hemorrhoidal vessels is occasionally found on the superior surface of the levator ani muscles, and is likewise clamped and ligated. The fascia on the superior surface of the levator ani muscles can be completely cleared and left with the segment of rectum. The coccygeal ligament likewise is divided. The completion of this pelvic dissection with all tissue planes under direct vision leaves only the perineal and levator ani attachments to the low rectal segment. The lower part of this dissection is much more easily accomplished from above than by the perineal route. It can be accomplished with less bleeding and with a greater surety that as wide a resection of all of the perirectal components is performed as is possible.

Peritonealization. It will be noted that in planning the extent of the pelvic dissection no attempt is made to save the pelvic peritoneum, yet one finds little difficulty in obtaining adequate peritoneum for establishing a relaxed pelvic



Fig 253. The anterior peritoneal incision high on the posterior surface of the bladder has been made. The seminal vesicles are displaced forward and Denonvilliers' fascia incised.

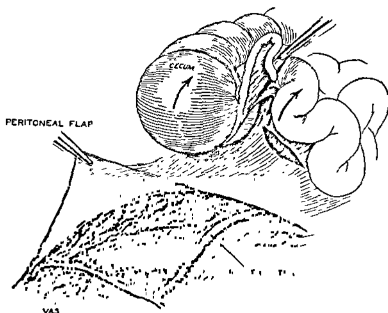


Fig. 254. A low attachment of the terminal ileal mesentery is indicated It is freed and the transverse peritoneal incision is then closed vertically. The peritoneal flap on the right has been freed to the junction of the vas deferens and spermatic vein at the internal ring. The ureter lies on the right lateral wall.

peritoneal floor. The lateral pelvic peritoneal flaps are now elevated, leaving the ureters attached to the lateral walls of the pelvis (Fig. 254). This peritoneal dissection can be carried as far to each side as desired. In the male patient the

dissection is carried to the internal inguinal ring where the spermatic vein joins the vas deferens (Fig. 254). In the elderly male patient with demonstrated prostatic enlargement it may be advisable to ligate the vasa deferentia. The dissection of the peritoneum covering the bladder can then be carried anteriorly and if considerable peritoneum is required, this dissection can be carried as far forward as the lower limits of the anterior abdominal incision (Fig. 255). The entire freeing of the pelvic peritoneal flaps can be carried out bluntly with the exception of the attachment to the bladder in the median line and the remains of the urachus which must be divided with a sharp dissection. In the female patient when the uterus is not removed, the dissection of the peritoneal flaps extends under the ovarian vessels, freeing up the entire infundibulopelvic ligaments and

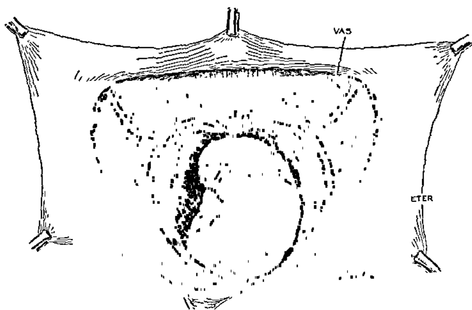


Fig. 255. Wide dissection of the lateral and anterior peritoneum is shown. The segment to be resected is reduced into the pelvis.

carrying the dissection as far forward as the round ligaments. When the uterus has been removed the same type of dissection is done in the female as in the male. If the peritoneal flaps are dissected as widely as is regularly feasible, rarely is there any difficulty in reducing into the pelvis the entire segment that has been freed up for resection (Fig. 255). This is a great advantage since division of the mesentery to the rectosigmoid segment may result in implantation of malignancy in the pelvis or perineum. The bowel is now divided at the previously selected point and the lower end ligated and covered with rubber dam, following which the entire segment is reduced into the pelvis (Fig. 255) with the leading point at the level of the coccyx being the free end for ready accessibility during the perineal resection. With adequate pelvic and peritoneal flaps, reconstruction of a pelvic peritoneal floor becomes a simple matter (Fig. 256). Care must be taken to cover the superior hemorrhoidal stumps in their retroperitoneal position. Utilization of the uterus for peritonealization is rarely necessary. The left brim of the pelvis is closed by anchoring the upper border of the left pelvic peritoneal flap to the pericolic fascia below the mesocolon and descending or sigmoid colon (Fig. 256).

With the completion of the pelvic peritonealization one should again observe the position of the ileomesentery to make certain that it has not been drawn down into the pelvis.

Colostomy. The proximal colon is now brought up through the original incision and the lateral gutter closed (Fig. 256). This is accomplished by suture of the visceral peritoneum that has been left on the descending colon and sig-

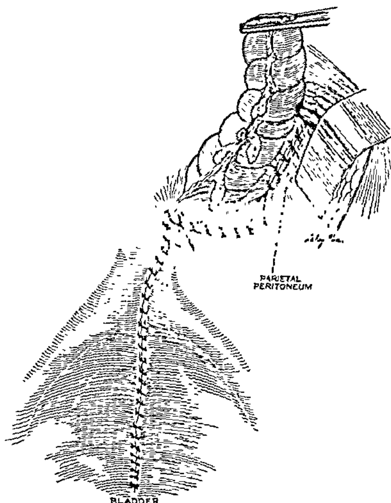


Fig 256. The lines of suture of the pelvic peritoneal flaps are demonstrated. Their closure is variable. The peritoneum over the left brim of the pelvis is attached to the pericolic fascia below the colostomy. The lateral gutter is closed.

moid, to the parietal peritoneum, and the line of suture should be passed slightly upward as it emerges, to form a diaphragm against which small intestinal loops may rest. The amount of emergence of the colon for establishing the colostomy can be varied as necessary in carrying out this procedure. There should be no redundancy of colon and the bowel should make a gentle curve up to its point of emergence. Unless technical difficulties are encountered, routine appendectomy completes the intra-abdominal portion of the operation. The wound is then closed in layers and appendices epiploicae of the projecting bowel are anchored into the peritoneal suture line both above and below the colostomy (Fig. 257). This is an additional precautionary measure to avoid wound disruption. The fascial layer is closed with 30 to 34 alloy steel wire. The colostomy should project at

least an inch and a half above the level of the skin (Fig. 257). Care must be taken to close the wound loosely about the colon and, when completed, one should be able to introduce a finger laterally below the closure of the lateral peritoneum without appreciable compression. Dry gauze is placed loosely about the projecting loop and abdominal pads placed above it to contain the clamp. Five factors have been employed to maintain the colostomy in the desired position: (1) closure of the lateral gutter; (2) incorporation of the appendices epiploicae in the peritoneal suture line; (3) the normal adherence of the bowel to the adjacent abdominal wall; (4) dry gauze placed about the colon and (5) a clamp on the end of the colostomy.

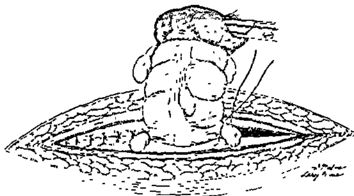


Fig 257. The colostomy projects beyond the wound. Appendices epiploicae are enclosed in the peritoneal suture line.

If some degree of obstruction exists, immediate decompression of the colostomy is performed by the insertion of a catheter. If diverticulosis is present in the proximal bowel, it is similarly decompressed.

Perineal Portion

While closing the abdominal wound it may be advisable to give a vascoconstrictor drug approximately five or ten minutes before the beginning of the perineal part of the operation. The patient is placed on the left side in a modified Sims' position with the left leg extended and the right leg flexed. The body should be at right angles to the table. If desired, a strip of adhesive may be used to hold the upper gluteal region upward. The shifting of a patient from the recumbent position to the side is not accompanied by any appreciable change in the blood pressure level, particularly if a vasoconstrictor drug has been used. A soap and water, alcohol-ether-zephiran preparation is used for the perineal field, with preparation of the vagina with zephiran. A purse-string suture is used to close the anus, following which an elliptical incision is made, extending from the tip of the coccyx posteriorly to the perineal region anteriorly (Fig. 258, *a*). A transverse incision is then made below the coccyx, entering the pelvic space (Fig. 258, *b*). The branches of the internal pudendal artery are divided, removing the fat from the ischiorectal fossa, exposing the full inferior surface of the levator ani muscles. It can then be demonstrated by inserting the finger posteriorly and extending it forward that the entire levator ani muscle has been uncovered from above. The posterior two-thirds of the levator ani muscles are then severed at

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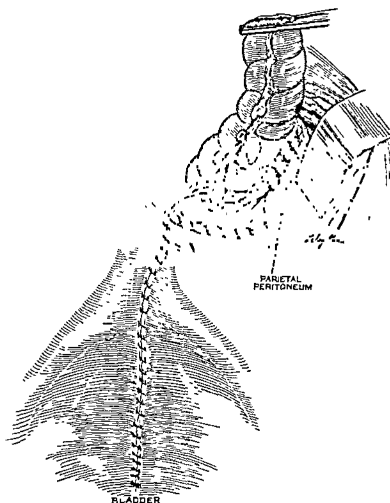


Fig. 256. The lines of suture of the pelvic peritoneal flaps are demonstrated. Their closure is variable. The peritoneum over the left brim of the pelvis is attached to the pericolic fascia below the colostomy. The lateral gutter is closed.

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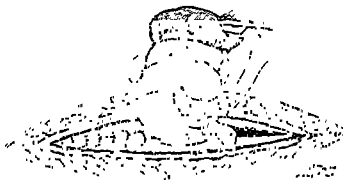


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their lateral attachments (Fig. 259), following which the entire segment of bowl is delivered from the pelvis (Fig. 260). At this point the ligated middle hemorrhoidal pedicles can readily be visualized, as can the vesicles and prostate (Fig.

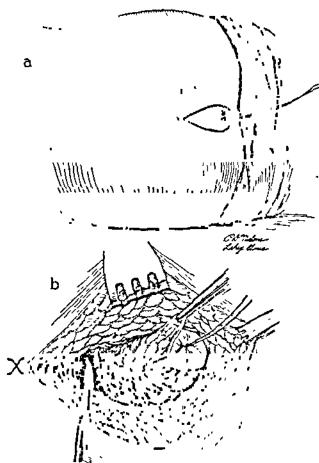


Fig. 258. *a*, Closure of the anus and limit of the perineal incision. *b*, Transverse incision into the pelvic space is made below the coccyx.

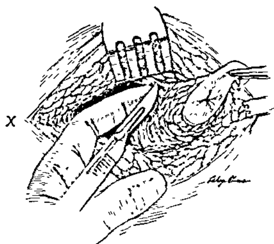


Fig 259. The posterior portion of the levator ani muscle is cut as far laterally as possible.

261) in the male and the vagina in the female, all of which have been freed from above. By retraction of the anal segment backward, the attachments of the transverse perineal muscles are severed following which, under direct vision, the

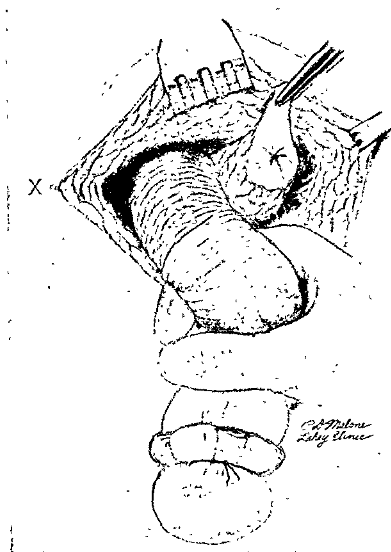


Fig. 260. The specimen is delivered easily through the small perineal incision.

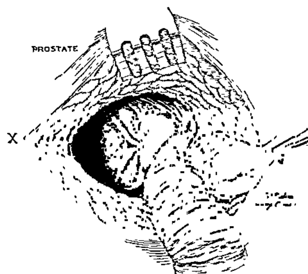


Fig. 261. The remaining attachments of the rectal segment are the transverse perineal and anterior third of the levator ani muscles.

anterior third of the levator ani muscle is divided on each side, with removal of the segment of bowel (Fig. 261). If the lesion is in close proximity to the posterior vagina with or without demonstrable invasion, the perineum and posterior vagina are resected with the lesion. Visualization of the pelvic space for possible bleeding is readily accomplished. A small Penrose drain with 2 or 3 cm. of gauze projecting, placed at the level of the cervix or seminal vesicles (Fig. 262, *a*) is

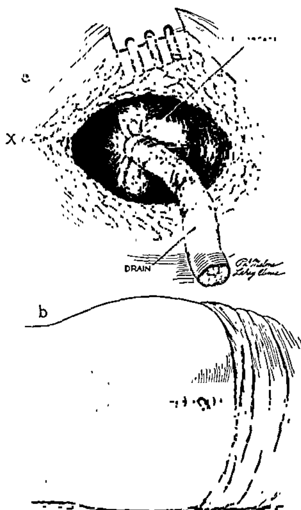


Fig. 262. *a*, Satisfactory hemostasis has been obtained. A small drain is brought out from the level of the seminal vesicles or cervix. *b*, Wound closure.

then brought out through the middle of the incision, which is closed loosely about it (Fig. 262, *b*).

POSTOPERATIVE CARE

When adequate blood replacement has been given preoperatively, usually one transfusion during operation suffices. Further transfusion may be required during the postoperative period. A retention urinary catheter is inserted and closed drainage instituted. Antibiotics are given in the form of streptomycin, 0.5 gm. twice a day for four days, and crysticillin, twice daily in amounts of 300,000 units for the same period. Usually, bladder drainage is continued for six or seven days. The colostomy is decompressed after thirty-six hours and the clamp finally re-

moved on the fourth postoperative day, at which time the first dressing is done. On the fifth day a laxative, in the form of small doses of milk of magnesia, is given and not repeated. The posterior drain is removed on the fourth day without re-insertion of any drain. Beginning on the sixth day the posterior wound is irrigated with a small catheter, utilizing a dilute iodine solution with a dram of 3.5 per cent iodine to a pint of saline solution. This serves for mechanical cleansing and has deodorant properties. Colostomy irrigations are begun on the seventh day and continued every second day thereafter. From the ninth day on sitz baths are utilized twice daily. Control of the colostomy is usually assured by the third irrigation and patients may be discharged from the hospital on the twelfth to fourteenth day, continuing on sitz baths daily. A low residue diet is utilized for the first month, following which the diet is gradually increased until it is entirely normal. Irrigations are continued every second or third evening as a permanent part of the routine care.

DISCUSSION

The operation of combined abdominoperineal resection, as described, has gradually evolved in this clinic, with a rather extensive experience with it. The percentage of patients submitted to resection has increased gradually over the past twenty years; at the beginning of the period approximately 50 per cent of patients with carcinoma of the rectum were submitted to resection and now, during the past five years, over 90 per cent have the rectal lesion removed. In spite of this far greater application of the procedure to the lesion the mortality has gradually been reduced and now remains under 5 per cent. Complications following the procedure have likewise diminished, with better preparation, with an improved operative procedure and with the use of antibiotics and improved postoperative care. Urinary complications still remain a prominent feature during the postoperative period. As the percentage of resected cases has increased with the inclusion of unfavorable cases, particularly the 12 per cent of the total who have liver metastases, satisfactory results in cases followed for five years or more have decreased so far as five-year percentage figures go. Without question, with the wider application of the procedure of abdominoperineal resection, a greater salvage of patients has resulted and much greater comfort has been produced in those patients who were incurable from the start, without increasing the mortality. From this experience, we believe that the abdominoperineal resection is the operative procedure of choice in all patients who have carcinoma of the low sigmoid, rectum and anus.

PRURITUS ANI

NEIL W. SWINTON AND JOHN L. FROMER

A review of the voluminous literature on the subject of anal pruritus reveals that nearly as many theories regarding the etiology of this condition have been advanced and methods of treatment advocated as there have been authors. Several conclusions might be taken from this. First, the final answer has not been written, and there may be several etiologic factors involved in many of the patients with this condition. Secondly, because so many preliminary good results have been reported following so many apparently different types of therapy directed primarily toward the perianal region, the treatment of the patient, in addition to the management of the local anorectal condition, may be an important factor. Thirdly, there may be a factor common to many of these apparently different types of treatent that has been overlooked by the attention given the variety of drugs, injections and surgical procedures used on the perianal area.

The fact that many of these methods are not permanently successful is apparent in that a large number of the patients seen at the Lahey Clinic have already had some type of local anorectal therapy for anal pruritus without more than temporary relief.

It is not the purpose of this paper to announce that a cure for every patient with anal pruritus has been discovered or to present a long statistical study, but it is a condition that is often seen and one in which we have been particularly interested for several years. Many of the studies reported in the literature have not been carried out, and there are many types of treatment that we have not utilized, it is a frequent complaint, however, and many of the intractable cases present serious and complicated problems.

As a result of this experience we have developed certain theories regarding the etiology of this condition and methods of treatment. It is the purpose of this presentation to discuss the factors that may give rise to anal itching or may cause an anal pruritus to become an intractable and definite pathologic entity, and to present the methods of treatment that have proved most satisfactory.

ETIOLOGY

Some precipitating factor begins an anal pruritus. An anal itching is often noticed following a period of diarrhea or constipation, particularly if there is some associated anorectal disease. It is also a frequent observation that fatigue, worry and nervous tension are associated. Usually, this itching is transient and causes only mild and temporary discomfort.

The natural tendency for relief of an anal itch is to rub or scratch, which, if continued, causes local congestion, trauma and irritation and allows the introduc-

Revision of article originally published in New England Journal of Medicine, 236:169-172 (Jan. 30) 1947.

tion of infection into the perianal skin and adjacent tissues. This, in turn, causes more itching and sufficient excuse for further scratching and irritation of the part. Thus, a cycle of scratching and itching is established that, in the long-standing, intractable case, may develop into such a habit fixation that the patient is powerless to let himself alone and is awakened from a sound sleep, scratching himself.

This scratch-itch syndrome is a basic factor in the background of a large number of patients with an intractable anal pruritus and must be thoroughly appreciated by both the physician and the patient. Patients with an intractable condition of this type who have been treated by several physicians with various remedies often state that no one had ever taken the time to emphasize the importance of the avoidance of irritation to the parts affected. It is our belief that many of the intractable cases would never have developed if this single principle had been followed in the early stages of the disease.

Scratching is not the only cause of pruritus ani—it is an important factor, particularly in intractable cases, but it must not be overlooked that something additional caused the original itch. In intractable cases this precipitating factor may have disappeared or become so altered by the passage of time and the development of local perianal changes that it is no longer significant, but it must be remembered that at one time there were factors favorable for the development of an itch in this region. It must also be recognized that the incidence of recurrence in this disease is high following alcohol injections, undercutting operations and other procedures in which a definite cessation of itching and relief from the tendency to scratch have been established, indicating that there are other underlying factors than the mere scratch-itch syndrome.

A wide range of factors may be responsible for the development of anal pruritus, and in long-standing intractable cases many factors may be involved in a single patient. Stokes[1] has divided into five groups the factors that should be considered in establishing the etiology of a given case of anal pruritus. These are considered below.

Physiologic Factors. The anorectal region contains a sweat apparatus called the apocrine system which, similar to the axillary, submammary and periumbilical areas, is a part of the sexual glandular system and has, among others, two important characteristics: the sweat contains protein and excess carbohydrate and is more alkaline than ordinary sweat, and the apocrine sweat glands are peculiarly responsive to emotion, particularly sexual tension. This area, with its high-protein and high-carbohydrate content and alkalinity, is thus an ideal medium for the introduction of fungous infections and secondary invaders.

The physiologic state of the gastrointestinal tract itself may be important. It is not unusual to find that a stubborn constipation or diarrhea—owing to an atonic or spastic bowel—aggravates an anal pruritus.

There has been considerable discussion on the effect of intestinal flora on this condition. We have had little experience with studies of the intestinal flora and, in general, have not been impressed with the importance of this factor. We have had no experience with the use of autogenous vaccines. It has seemed sufficient to establish a normal bowel function, and adequate treatment of an irritable colon has been of value in the treatment of many stubborn cases.

It has been noted that many soaps are irritating in this condition. In patients

who have a deficient amount of fat in their normal skin secretion, the excessive use of soap often causes local irritation. The sodium salts of saturated fatty acids are relatively irritating, and the sulfite in certain toilet tissues has been reported as a frequent source of irritation.

Excessive carbohydrate intake not only predisposes to an increased alkalinity of the part affected but also causes an increased hydration of the skin. Excessive fruit juices may have the same effect. Alcohol, as a peripheral dilator, may be significant.

Infective Factors. The role of fungous infections in anal pruritus has received considerable attention.[2] Terrell and Shaw[3] reported an incidence as high as 60 per cent in cultures taken from the perianal area. In the few patients in our series on whom careful bacteriologic studies were made, the incidence of fungous infections was not high. Pyogenic flora, with occasional hemolytic streptococci, were the usual findings. Stokes[1] has pointed out that a variety of organisms may be associated with the disease, many of which, generally considered nonpathogenic, seem to become pathogenic for the patient concerned.

Allergic Factors. An allergic background has been encountered in a few of our patients with anal pruritus. Frequently, however, the exact relation of the anal itching is difficult to evaluate. Certain patients exhibit an apparent susceptibility to certain food allergens. A contact sensitivity to mercury, found in many of the surgical lubricants, and the absorption of phenolphthalein, frequently used in laxatives, may cause local sensitization and pruritus

Psychogenic Factors. The importance of psychogenic mechanisms should never be overlooked in anal pruritus. Nearly every patient with an intractable anal itch presents a history of episodes causing tension. The relation of fatigue and worry can be noted in every patient and financial upsets, family maladjustments and frustrations are frequently observed. A patient with a long-standing anal pruritus usually develops a fixation on the anal area to such an extent that any upsetting influence to his existence is reflected by an anal itch, and his entire attention may be directed either to the actual itching or to the anticipation of the next episode of difficulty. This fixation may become so serious that the patient is on the verge of complete mental collapse. Such patients are desperate for lack of rest, are completely incapacitated and require immediate and serious attention.

Stokes mentions the anal erotic type of anal pruritus, which we have encountered in a small number of patients, usually young men. Sexual problems may enter into many of these cases.

Anal pruritus was an extremely rare disease in the Armed Forces as compared with its incidence among civilians. In our experience, which was largely confined to combat infantrymen but included many thousands of hospital admissions, there was only one patient who presented intractable anal pruritus; he was obviously maladjusted, and his one desire was to be transferred out of the combat zone. The majority of these men, experienced infantrymen, had the highest morale and were too busy and occupied most of the time to develop an anal fixation and spend their time worrying and itching and scratching. It must be remembered that these men were frequently without baths or clean clothes for days at a time and were in a hot, humid climate.

Mechanical Factors. Nearly every case of anal pruritus is precipitated by

some local mechanical factor. If this itching begins when certain other favorable factors exist and relief is not obtained, the condition may become intractable.

Minor trauma to this area is not unusual. The act of defecation may cause an abrasion or a fissure. The effects of instrumentation, rubbing or scratching may begin an itch. Hemorrhoids may be responsible, but probably less frequently than has been believed. Large skin tabs, however, by rubbing together, causing congestion and interfering with mechanical cleanliness of the area, often seem to be important.

A contracted anal ring, a condition referred to in the literature as pectenosis, is a frequent factor. Infected or inflamed crypts are rarely involved, in our experience.

TREATMENT

A general physical examination, including an anoscopic and proctoscopic examination of the lower bowel, should be done in all cases. Routine blood counts and a urine examination should be carried out. In the majority of cases, after examination, the cause will be obvious and the treatment apparent. In many, however, further laboratory and roentgenologic studies will be required and possibly the help of the dermatologist, internist, gastroenterologist or psychiatrist. It is to be noted that the original or precipitating factor in the long-standing case of anal pruritus may have disappeared and, from the standpoint of therapy, may not be particularly significant.

For constitutional treatment, the most important requirements are adequate rest, relaxation and relief from tension. Hospitalization and temporary but adequate sedation may be necessary in severe cases. A small amount of a combination of a tincture of belladonna and luminal, particularly when there is an associated spastic colon, is a helpful sedative. The addition of an antihistaminic tablet or capsule at bedtime may allay the itching which is usually most intense at night. Chloral hydrate ensures a good night's sleep. A normal bowel function should be established as early as possible, and the intake of carbohydrate, excess roughage and alcohol should probably be reduced.

Excessive sweating, which may be troublesome, is the only indication for radiation therapy, since in our experience cases in which such therapy was used routinely nearly all recurred after a period of six to eight months of temporary relief, and it was found that they were invariably much more difficult to control. We have observed cases in which cancer developed in the anal area from the excessive use of radiation therapy. At the present time it is rarely used.

The presence of seborrhea, psoriasis, eczema, contact dermatitis and certain other strictly dermatologic conditions should not be overlooked. Special studies, particularly for food allergies, may be necessary in certain stubborn cases.

In considering local therapy, we are in entire agreement with Stokes that too much attention has been given to this phase of the management of the patient with anal pruritus. Most patients with long-standing intractable anal pruritus have had one or more series of radiation treatments, undercutting operations or alcohol injections, hemorrhoidectomy, cryptectomy, rectal dilatation or some other surgical procedure. They present a scarred anal ring and perianal area that has obviously been made worse by such treatment. Many of these patients had

never been instructed to keep themselves clean and stop scratching. Scarring and fibrosis of the anorectal area may follow chronic inflammation set up by the innumerable remedies previously applied to the area. Many of these medicaments are known sensitizers. These include the local anesthetics, that is, benzocaine, nupercaine and their analogues. A fair percentage of sensitization is caused by the continued application of antihistaminic ointments.

Several years ago, while doing an alcohol injection on a patient with anal pruritus, we had a visitor very much interested in the procedure and in the disease. She was a missionary who had been in charge of a hospital in India for many years and had never seen a native with an anal pruritus of the type described in the literature, the explanation, in her opinion, being the fact that the Indians had never known modern toilet tissue and merely washed themselves frequently. Certainly, adequate local hygiene is the basis of any local therapy for anal pruritus. That this is not the only factor, however, was borne out by the experience in the Army referred to above.

Our patients are routinely advised to wash themselves often with cotton moistened in warm water and to eliminate toilet tissue and soap. They are instructed never to touch themselves with their fingers or any object other than cotton. The ensuing dryness and cleanliness and the avoidance of trauma will indefinitely control many of the mild cases of anal pruritus.

Among the local medications, potassium permanganate, in a strength of 65 mg. to 1 liter of hot water, is used almost routinely. Patients with a mild pruritus are instructed to sit in a basin of this solution for fifteen to twenty minutes at a time as often as is necessary to control the itching. The usual cause of failure in the use of potassium permanganate has been that the solution has not been employed for a sufficient period. The application of a 1 per cent solution of phenol in calamine lotion may be all that is necessary to relieve the difficulty. In the severer cases, continuous wet dressings and hospitalization may be required. In the hospitalized patient, the slow intravenous infusion of a 0.2 per cent procaine solution may effectively interrupt the itch reflex. This measure exerts a continuous anesthetic, antipruritic and antispasmodic effect on the irritated, congested rectal area. To maintain the effect of procaine, the oral administration of pronestyl, a procaine amide, may be used as follow-up therapy. Burow's solution, containing 1 per cent alum and 3 per cent lead acetate, is mild and helpful. Castellani carbolfuchsin paint—containing carbolfuchsin, phenol, boric acid and water, with or without resorcinol—is satisfactory in many cases; at first it should be diluted 1:2 and 1·3. Extremes of heat or cold may give prompt relief in certain acute situations.

In general, nonirritating, bland solutions are used and greases and ointments avoided. When lubrication is required, castor oil or olive oil may be helpful but should be employed sparingly. Frequently, following the continued use of potassium permanganate soaks, the skin tends to become dried out and mildly irritated. If actual fissures develop, ammoniated mercury ointment or a 2 per cent silver nitrate solution may aid healing. The coal tar preparations are at times indicated. It is axiomatic in dermatologic therapy of chronic skin conditions that preparations may soon lose their efficacy even though they have proven successful in the control of pruritus. Hence the physician who is familiar with the use of a small

number of effective, nonirritating remedies is most successful in the management of anal pruritus. Furthermore, the active ingredients of any topical preparation may be applied in weak concentrations to be later increased according to the patient's tolerance. An explanation of this principle to the patient will instill confidence and prevent the widespread "shopping" from one physician to the next by these unfortunate sufferers.

There are definite indications for surgery in these patients, but as our experience with this condition has increased, surgery has been used less and less. Surgery should be directed toward the removal of sources of infection and the correction of obvious local disease. Infected crypts should be drained, a contracted anal canal should be corrected and large edematous skin tabs that interfere with local hygiene of the area should be removed. The routine removal of hemorrhoids relieves few patients. Anal fissures should be excised, and fistulas should be removed.

At a certain period in our experience with this condition, a number of the more serious cases were treated with alcohol injections. Both the technics described by Stone[4] and Buie[5] were used. Temporary relief was obtained in all patients. Permanent relief was apparently obtained in a high percentage treated with the Buie technic, particularly when sufficient alcohol had been given to cause an actual slough, with complete destruction of the skin. The excessive scarring resulting from many of these procedures, however, was certainly not desirable. We have had a limited experience with the injection of local anesthetic-in-oil preparations. Temporary relief of anal pruritus has also been obtained following the injection of large quantities of both saline solution and distilled water. We have had no experience with the local injection of oxygen, with any of the tattooing procedures or with the Ball undercutting operation or any of its various modifications.

It has seemed to us that one factor common to all these different procedures has not been sufficiently emphasized, namely, local anesthesia to the affected part. This gives definite relief from the scratch-itch syndrome and enables the patient to rest. The only real justification in these radical procedures is this common denominator. They should be reserved for the severe cases in which rapid complete rest and relaxation are imperative. It is our firm belief, however, that the incidence of recurrence will remain high if complete reliance is placed on these surgical procdures, and adequate attention is not given to the various factors that may be in the background and to the restoration of the perianal skin to its normal tone and consistence.

DOCTOR-PATIENT COOPERATION

When patients with anal pruritus are first seen they should be given a brief but intelligent discussion of the subject. In this way, the patients themselves are often able to suggest etiologic factors that obviate expensive study and consultation. The patients must understand that they are faced with what may be a chronic condition. They must learn to treat themselves and to forestall recurrence of the anal itching. It should be pointed out to them that rest, relaxation and freedom from nervous tension are essential for permanent relief and that the object of local treatment is to eliminate infection and to restore an irritated, infected area to its normal state. When surgery is indicated, the definite limitations

of the surgical procedure and its object should be pointed out. In many patients who present themselves with a long-standing anal pruritus for which they have been promised a cure following surgery, no attention has been given to any of the other factors that may have been responsible for the disease. The physician who regards the patient with an intractable anal pruritus as a neurotic and gives him no attention deserves little sympathy; the patient has a real disease that can be serious and disabling, but with a reasonable appreciation of the responsible factors and an intelligent approach to the treatment of the patient and the local condition, satisfactory results for this distressing condition can be achieved.

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THE BILIARY TRACT

OPERATIVE PROCEDURES ON THE GALLBLADDER AND COMMON DUCT

BENTLEY P. COLCOCK

With the development of modern surgical facilities and technics, cholecystectomy has become one of the most frequently performed of intra-abdominal operative procedures. The low mortality and morbidity associated with the average cholecystectomy have resulted in a tendency to regard this operative procedure rather lightly and to compare it to a routine appendectomy or hysterectomy. All surgeons of experience, however, particularly those who have been called upon to repair strictures of the common duct following cholecystectomy, are concerned about this light-hearted attitude often manifested toward this operative procedure. The possibility of an immediate or eventual fatality as a result of irreparable damage to the hepatic artery, the portal vein and particularly the common duct is inherent in every cholecystectomy. That this danger is not a theoretical one is evidenced by the fact that at the clinic we continue to see one to two new patients a week sent to us because of a stricture of the common duct resulting from injury to the duct at the time of their original cholecystectomy. Lahey has repeatedly emphasized the absolute necessity of an adequate exposure, a dry field, a good light and an accurate anatomical demonstration of the common, cystic and hepatic ducts, and hepatic and cystic arteries in all operative procedures in this area.

Surgery of the biliary tract has long been one of the major interests of this clinic. We believe that whenever gallstones can be demonstrated that patient should have removal of those stones, preferably by cholecystectomy. This includes the so-called silent stone. In our experience, many patients with gallstones which have been asymptomatic for years, have developed serious complications, such as perforation, obstruction, secondary liver damage and pancreatitis. Many of the complications of cholelithiasis, such as acute cholecystitis, common duct stones, internal biliary fistulas, and so forth, occur in patients who have known that they had gallstones and have been advised to have them removed but have neglected to do so. If we are going to adopt a policy of advising cholecystectomy whenever the diagnosis of cholelithiasis can be established, we must have a plan of management that is associated with a minimum of morbidity and mortality. In a review of 1104 cases over a five-year period ending in December 1945 the mortality rate at the clinic was 0.9 per cent.[1]

A second important characteristic of any technic for cholecystectomy should be an exposure which will permit opening and exploration of the common bile duct whenever any one of a number of indications is present. As we have widened our indications for exploration of the common bile duct, more common duct stones

Revision of article originally published in Surgical Clinics of North America, 29.805–815 (June) 1949.

have been found. We now explore the common duct in 45.7 per cent of all cases of cholelithiasis with an incidence of common duct stone being found in 16.8 per cent. Since 47 per cent of these patients with common duct stones did not have jaundice, if the common bile duct is explored only in the presence of jaundice, many patients who have a cholecystectomy will have an incomplete operation because of overlooked stones in their common duct. A second operative procedure probably will be required, and the risk of this second operative procedure is definitely increased because of the adhesions present, the continued liver damage and usually the presence of jaundice. We are convinced from an experience of over 1500 explorations of the common duct that, in the hands of surgeons trained in the surgery of the biliary tract, choledochostomy does not increase the operative mortality or appreciably increase the operative morbidity.

A third and most important aspect of a technic for operative procedures on the gallbladder and common duct is that the exposure must be such that injuries of the hepatic artery, the portal vein and the common bile duct are reduced to an absolute minimum. We have now operated on more than 250 patients with benign stricture of the common bile duct. In 85 per cent of these patients the stricture was due to an operative injury which had occurred at the time of a previous cholecystectomy. These patients with stricture of the common duct present some of the most difficult problems to be found in abdominal surgery. Any patient who has an injury to his common bile duct faces a certainty of a long period of invalidism, the probability of one or more serious abdominal procedures and the very real possibility of a definitely shortened life. In over 5,000 gallbladder operations in this clinic only one operative stricture has been produced.

CHOLECYSTECTOMY FOR CHRONIC CHOLECYSTITIS AND CHOLELITHIASIS

1. In the absence of jaundice or acute symptoms, most of these patients will not require extensive preoperative preparation in the hospital. Most will have had a gastrointestinal study to rule out disease of the stomach, duodenum and colon.

Any associated cardiovascular disease should be treated as adequately as possible before the patient is scheduled for operation. These patients are placed on a high carbohydrate, high protein, low fat diet.

2. The preoperative medication for a healthy, vigorous patient under 50 years of age is pantopon, $\frac{1}{3}$ grain, and scopolamine, $\frac{1}{150}$ grain, subcutaneously two hours before operation, and 3 grains of a short-acting barbiturate orally one hour before operation.[7] These doses are reduced for older and weaker patients and the patients over 60 are not given a barbiturate.

We believe that spinal anesthesia is the anesthesia of choice for all operations on the biliary tract. Not only does it provide the optimum exposure and relaxation so important for the surgeon when working in a deep wound in close proximity to such structures as the hepatic artery, portal vein and common duct, but, unlike deep general anesthesia, it has little or no deleterious effect upon the liver. This is important since many of these patients have long-standing hepatic damage secondary to their biliary tract disease. We have no concern relative to the use of spinal anesthesia in the upper part of the abdomen since all anesthetics are given

by a competent physician anesthetist and the level of the anesthesia is accurately controlled by the use of a pontocaine-glucose mixture. For patients with common duct stricture, fractional spinal anesthesia, using pontocaine solution, is often employed. In addition to the spinal anesthesia, these patients are often carried under very light general anesthesia so that they will be oblivious to what goes on about them.

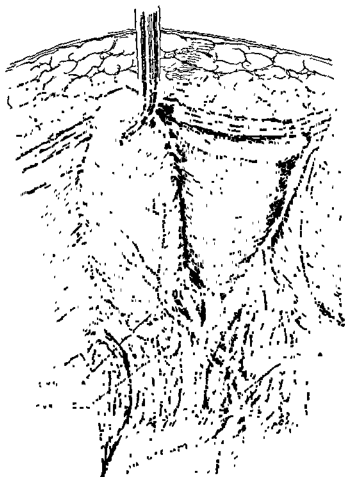


Fig. 263. Operative field. The abdominal viscera are retracted to the patient's left, the gallbladder is retracted upward and to the right and the cystic artery and cystic duct will be exposed after reflection of their peritoneal covering. It will be noted that the cystic artery will have to be clamped and divided before the convolution of the cystic duct can be straightened out, permitting clear visualization of its junction with the common duct.

3. Incision. The type of operative incision is not important except that it must be of sufficient length to afford adequate exposure and admit adequate light to the region of the cystic duct, cystic artery and common duct. In an obese individual or patients with wide flaring costal margins, these structures may lie at considerable distance from the surface of the abdomen. At the clinic we use either a right rectus muscle splitting incision or a right paramedian incision, retracting the rectus muscle.

4. Exploration. The peritoneal cavity is opened, and the abdomen is thoroughly explored. Most of our patients with disease of the biliary tract will have had a complete gastrointestinal study before coming to operation. Nevertheless, it is our custom to palpate carefully the liver, pancreas, kidneys, stomach, duodenum,

colon and rectum before starting the cholecystectomy. If the *exploration* is negative and the diagnosis of cholelithiasis is substantiated by the presence of stones in the gallbladder, a Pennington clamp is placed on the gallbladder and the right lobe of the liver rotated downward and outward by breaking the suction between the dome of the right liver and right diaphragm. The stomach, duodenum and transverse colon are then retracted medialward and downward to the patient's left. When the duodenum and hepatic flexure are retracted to the left, the hepatic and common ducts are put on the stretch, the foramen of Winslow

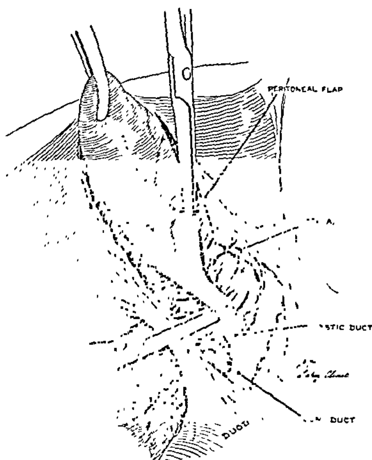


Fig 264. The flap of peritoneum has been reflected along each side of the gallbladder bed, the cystic artery divided and ligated and the junction of the common and cystic ducts isolated, permitting the latter to be divided and ligated flush with the common duct and the gallbladder removed from below upward.

becomes visible, and one can obtain a clear view of all the important structures that must be dealt with during the course of the procedure (Fig. 263). Finally, before dissection is started, a moist gauze sponge is placed down to the region of the foramen of Winslow to collect any blood or bile which might escape and drain into the lesser peritoneal cavity.

With a second clamp placed on the ampulla, the gallbladder is elongated and a flap of peritoneum reflected on each side. Later, this will be used to peritonealize the gallbladder bed which we feel is important in preventing adhesions to the duodenum and pylorus with resultant disturbance in gastric function. Unless we are dealing with acute cholecystitis, we prefer to remove the gallbladder from

below upward. Accordingly, our next step is to incise the peritoneum over the gastrohepatic ligament and isolate the cystic artery which is then clamped and divided. By securing the cystic artery first, three things are accomplished: (1) the subsequent dissection is carried out in a relatively dry field; (2) when the cystic artery is divided and released from the gallbladder, the convolutions of the cystic duct can be straightened out and the junction of this duct with the common duct more clearly and accurately defined, and (3) it eliminates the danger of serious bleeding from tearing the cystic artery through traction on the gallbladder. A careful review of the operative notes concerning the original cholecystectomy on patients sent to us for repair of common duct stricture indicates that serious bleeding from the cystic artery during the operative procedure was a frequent occurrence. Almost invariably in these patients the site of stricture in the common duct will be found close to the point where it is crossed by the cystic artery, strongly suggesting that in securing hemostasis the common duct itself had been caught in the hemostats.

After the cystic artery has been divided and the cystic duct placed on tension, its junction with the common duct can be clearly demonstrated so that the duct can be clamped, divided and ligated (Fig. 264). This is done at a point close to the common duct so that no stump of cystic duct will be left in which stasis and subsequent stone formation might occur and at the same time not so close as to cause any impairment of the lumen of the common duct. We feel strongly that the clamping of both cystic artery and cystic duct at one time with the same instrument is a practice which should be abandoned. After the cystic duct has been divided the gallbladder is then removed from below upward, carefully clamping any accessory blood vessels or accessory bile ducts which may enter either the cystic duct or gallbladder from the liver bed. We believe that it is the discharge from such divided accessory bile ducts rather than a slipped ligature on the cystic duct which occasionally gives rise to biliary peritonitis. Since many of these small ducts will not drain bile immediately and are easily overlooked, we invariably add the further safeguard of placing a Penrose or cigarette drain down to the foramen of Winslow at the completion of the cholecystectomy.

If choledochostomy is not indicated, the peritoneum of the gastrohepatic ligament is then approximated over the stump of the cystic duct and cystic artery and the peritoneal flaps previously reflected are sutured over the gallbladder bed. If the appendix is present, we routinely remove it provided it can be safely done through the existing incision. The incision is then closed in layers.

CHOLEDOCHOSTOMY

1. The various indications which, in our opinion, call for exploration of the common duct in patients with cholelithiasis have been reviewed elsewhere.[4] Briefly, these indications are: (1) the presence or history of jaundice, (2) a dilated or thickened common duct, (3) presence of small stones in the gallbladder, (4) positive or suspicious findings on palpation of the common duct, (5) sediment in the bile aspirated from the common duct, (6) acute or subacute pancreatitis and (7) a noncalculus gallbladder with biliary tract symptoms such as colic. A surgeon operating on a patient for cholelithiasis must make every effort to be certain that the entire biliary tract is left free of calculi

before completing the operative procedure. At the present time we explore the common duct in 45.7 per cent of all patients with cholelithiasis.

Fifty-three per cent of our patients who have common duct stones are jaundiced or give a history of jaundice and all patients with common duct stones should be assumed to have some degree of liver damage. If an appreciable degree of liver damage is present, these patients will require several days of preoperative preparation. Anemia must be corrected, the serum protein determined and restored to normal, or as near normal as possible. If jaundice is

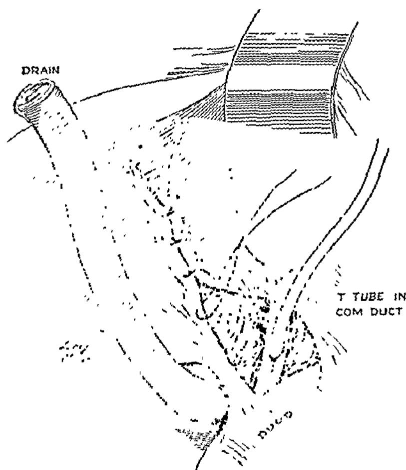


FIG. 265. The common duct has been explored below the stump of the cystic duct and the incision closed about an indwelling T-tube. The peritoneum will be approximated over the gallbladder bed and over the ligated cystic duct and artery and common duct. The drain is placed down to the foramen of Winslow.

present these patients should receive from 4.8 mg. to 9 mg. per day of synthetic vitamin K by intramuscular injections. Vitamins A and B are also given since these patients are often deficient in this respect and the electrolyte balance, particularly serum chloride, should be checked and restored to normal limits before operation.

2. The same exposure which we believe is an essential part of a cholecystectomy will also provide adequate exposure for choledochostomy. The incision in the gastrohepatic ligament to expose the junction of the cystic and common hepatic ducts will expose the anterior surface of the common duct through which exploration is to be carried out. We believe that the common duct can

be more adequately explored through a longitudinal incision in its anterior surface than through the stump of the cystic duct. The suction tip is held close to the duct so as to prevent spillage of bile when the duct is opened. A sponge has already been placed in the foramen of Winslow to prevent any bile or blood draining into the lesser omental cavity. The margins of the duct incision are held apart by long Allis type forceps, the teeth of which have been removed. The right and left hepatic ducts are first explored with the sound to demonstrate their patency. Scoops and forceps are then used to remove any stones or detritus from the lower end of the common duct. When we are satisfied that the common duct is clear, the ampulla of Vater is gently dilated by graduated Bakes dilators to a size somewhat less than that of the duct and any remaining sediment washed through into the duodenum by a catheter. No force is used in dilating the ampulla. As soon as the smallest dilator has gone through, the subsequent dilators are molded to the same curve and passed in the same direction until the desired dilatation has been obtained.

3. We do not close any common duct without drainage and we prefer a T-tube to a catheter for this purpose (Fig. 265). If fibrosis and stenosis of the ampulla have been found, a long arm T-tube[2] with one limb of the T passed through the ampulla well down into the duodenum is used to maintain the dilatation of the ampulla until all danger of secondary constriction is passed. This procedure should be seriously considered whenever a patient is operated upon for symptoms which suggest the presence of a common duct stone and no stone or stricture is found. These long arm T-tubes are often left in for six to nine months.

4. For the average patient a tube with the cross arm cut very short is inserted and the incision in the duct closed about it by fine interrupted sutures. The T-tube is clamped for one hour on the seventh postoperative day and this period is doubled each day until it is clamped continuously. If the patient's stools have resumed their normal color it is removed about the twelfth postoperative day. If there has been marked dilatation of the common duct or evidences of severe cholangitis, the T-tube may be left in for as long as three to six months. If many stones have been found in the common duct, a cholangiogram is usually made before the T-tube is removed to make certain that no stone has been overlooked or has passed down from the intrahepatic portion of the biliary tree following the choledochostomy. If the patient is being sent home with the T-tube in, he is instructed either to open the T-tube at night and allow it to drain into a bottle at the side of the bed or to irrigate the tube twice a day to maintain patency.

5. Choledochostomy has not increased the mortality or appreciably affected the morbidity following cholecystectomy, and the advisability of exploring the common duct should be carefully considered in every patient subjected to cholecystectomy for cholelithiasis.

COMMON DUCT STRICTURE

Stricture of the common duct as a result of injury to the duct during the performance of cholecystectomy presents one of the most difficult problems encountered in abdominal surgery. We have had considerable experience with

these patients and this experience has been reviewed in detail by Lahey[5] and by Cattell.[3] The most important aspect of this problem is its prevention and the value of good anesthesia, adequate exposure and careful anatomical dissection in the prevention of common duct stricture has already been emphasized.

As Lahey has pointed out, the prospect of obtaining a good surgical result in these patients who have a stricture of the common duct will depend upon the type of injury to the duct, whether or not a previous attempt at repair had been made and whether irreparable liver damage has occurred as a result of repeated and long continued obstruction and infection of the biliary tract. Cattell[3] has

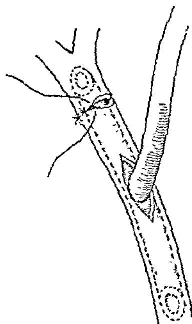


Fig. 266. This illustrates the most desirable type of repair following stricture of the common duct. An end-to-end suture of the duct itself is being carried out, thus preserving the sphincter mechanism at the ampulla. The T-tube will maintain the patency of the anastomosis until all danger of narrowing of the anastomosis is passed. It should be noted that the long arm has been brought out the normal portion of the common duct so that its withdrawal will not affect the area of anastomosis.

pointed out that two general methods of repair are available; first, anastomosis of the proximal end of the duct to the gastrointestinal tract, that is duodenum or jejunum, and second, restoration of continuity of the duct by suture at the proximal and distal ends over a tube, thus preserving the normal sphincteric action at the lower end of the duct. In our experience, repair by the second method is the method of choice and will give the best results whenever it can be accomplished. He has pointed out that frequently this can be accomplished, even though apparently no lower segment of common duct remains. By completely mobilizing the first and second portions of the duodenum and occasionally splitting the head of the pancreas in order to develop the undamaged lower portion of the common duct it is frequently possible to carry out an anastomosis of the two ends over one arm of a T-tube. It is important not to bring the vertical limb of the T-tube out at the site of the anastomosis but through an incision in the duct below this point so that its subsequent removal will not damage the

suture line (Fig. 266). These tubes are left in place for at least six to twelve months.

CHOLECYSTECTOMY FOR ACUTE CHOLECYSTITIS

1. In acute cholecystitis we believe that surgery as soon as the patient's general condition will permit, preferably within forty-eight hours following the onset of symptoms, will be associated with a lower mortality and lower morbidity rate than will the policy of waiting until the acute process subsides. These patients should be admitted to the hospital promptly, fluids and glucose by vein started immediately, and operation carried out as soon as any existing dehydration or disturbed blood chemistry has been restored to as near normal as possible. In a series of 74 pathologically proved cases of acute disease of the gallbladder reported in 1948, there was one postoperative death, a mortality of 1.3 per cent.[6]

2. The usual cholecystectomy incision is made and the usual exposure obtained. The edema in the gallbladder wall usually prevents any attempt at the reflection of peritoneal flaps with which to reperitonealize the gallbladder bed. Contrary to our usual custom of retrograde removal of the gallbladder, in most of these patients, because of the amount of edema surrounding these important structures, we believe it is safer to dissect the gallbladder from its bed, beginning at the fundus and proceeding down to the cystic artery and common duct.

In patients with markedly distended gallbladders, better exposure of the cystic artery and duct may be obtained by first emptying the gallbladder with suction. The fundus is punctured with the trocar suction tip and when the gallbladder is empty the puncture wound can be closed by a clamp as the suction is withdrawn, preventing any spillage of bile.

3. Common duct stone as a complication of acute cholecystitis is not uncommon and in the previously reported series of 74 patients, a common duct stone was found in 16.8 per cent. In other words, common duct stones are just as frequently found associated with acute cholecystitis as with chronic cholecystitis, and the exposure and dissection should be such in these patients as to permit cholecystostomy when indicated just as when operating for chronic cholecystitis and cholelithiasis.

4. Whenever possible we prefer to carry out cholecystectomy for acute cholecystitis. Occasionally, because of the patient's condition, it may be necessary to do only a cholecystostomy. In these patients, the fundus is exposed and carefully walled off from the rest of the peritoneal cavity. A small incision is made in the dome of the fundus and the gallbladder emptied. The margins of the incision are then held open by Allis forceps and scoops and gallbladder forceps used to empty the gallbladder of stones. Occasionally the only stone present will be a small one wedged far down in the cystic duct. This should be removed if possible. A large catheter is then placed in the opening of the gallbladder and the opening closed about it by two or more inverting purse-string sutures. The catheter is then brought through the omentum and out through the upper portion of the incision.

5. Patients with acute cholecystitis are usually given penicillin postoperatively. At the present time we are using 300,000 units given in one injection daily (crysticillin). Many of these patients are aged and may have associated cardio-

vascular disease. They should be carefully watched from this point of view following their operative procedure.

SUMMARY

Gallbladder surgery is major surgery. It should not be attempted by the occasional operator or by any surgeon who is handicapped by insufficient experience or inadequate facilities. When performed by a competent surgeon with good light and adequate exposure, it is associated with a low morbidity and mortality rate, and is a credit to modern abdominal surgery.

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THE USE OF A LONG T-TUBE IN SURGERY OF THE BILIARY TRACT

RICHARD B. CATTELL

Obstruction of the biliary ducts is a common finding during surgery of the biliary tract. Calculi are the usual cause of this obstruction but less frequently benign stricture or malignancy is responsible for the obstruction. Exploration of the extrabiliary ducts, usually through the common duct, is necessary in a considerable number of patients operated on for gallstones. In a recent survey[1] of patients operated on for gallstones at the Lahey Clinic, the common duct was explored and drained in 504 patients of a total number of 1104 patients, an incidence of 45.7 per cent (Table 1). It will be seen from this Table that common

Table 1. Gallbladder Operations

		COMMON DUCT EXPLORATION		COMMON DUCT STONES		OPERATIVE MORTALITY	
YEARS	GALLBLADDER PATIENTS	Cases	Per cent	Cases	Per cent	Cases	Per cent
1930–1933 ..	493	198	40.2	98	20.0	11	2.2
1934–1937 ..	634	284	44 8	103	16.2	20	3.1
1938–1941 ..	909	444	48.8	128	14.1	21	2.3
1942–1945 ..	1104	504	45.7	186	16.8	10	0.9

duct exploration is considered necessary in nearly one half of the patients operated on for gallstones in this clinic. This can be contrasted with an earlier experience reported by the author[2] twenty years ago when only 15 per cent of patients had common duct exploration.

It is a common surgical practice to drain the common duct by a catheter or T-tube. In this clinic we utilize a T-tube in all cases, and have experienced little difficulty with its removal. In only one out of over 2000 patients having T-tube drainage was any difficulty experienced in its removal. In this one patient, the T-tube broke off 2 cm. above the transverse limb, and was removed by reopening the wound. The common duct incision may be closed primarily by suture without the utilization of a tube, but this method has no particular advantages.

Some patients are not relieved by clearing the duct system of sediment, sand and stones because obstruction at the papilla of Vater is not relieved. Under these circumstances, when the gallbladder has previously been removed, the formation of stones within the biliary ducts can be proved. Approximately 4 per cent of the patients having common duct stones do not have stones in their gallbladders, which offers further evidence of their formation within the duct.

When forcible dilatation of the sphincter of Oddi and papilla of Vater is

Originally published in Surgical Clinics of North America, 28·659–668 (June) 1948.

necessary, it is always accompanied by submucosal hemorrhage and edema. This may be followed later by fibrosis, resulting in the same or greater degree of narrowing than originally was present. Relief of the back pressure of bile by means of a T-tube during this period of mechanical and inflammatory swelling at the papilla is generally accepted as the best means of avoiding difficulty but may not be a sufficient safeguard against its recurrence.

In all instances of common duct exploration the entrance of the common duct into the duodenum should be carefully explored to determine its patency or degree of narrowing. Gentle dilatation of the papilla by means of graded sounds, such as the Bakes dilators, will provide information as to the size of the opening. When the duct opening does not permit the passage of a probe, either because of narrowing or an angulated course, it may be necessary to open the duodenum and dilate it or cut the sphincter of Oddi under direct vision.

Under both of these circumstances, first, when forcible dilatation of the ampulla is performed or second, when the sphincter has been divided by transduodenal exploration, it is best to have an indwelling tube or mold through the traumatized area of the papilla for varying lengths of time, depending on the disease present. A long catheter passed distally through the duct can be used, but a T-tube with a long horizontal limb, permitting direct passage of bile into the duodenum is greatly to be preferred.

Ten years ago, a T-tube with a long horizontal limb was devised to answer this problem. Since that time it has found many satisfactory uses in biliary tract surgery, some of which have previously been presented.[3]

THE LONG T-TUBE

The conventionl T-tube has a 4½ inch transverse limb. The long T-tube has a 12 inch horizontal limb, which is the approximate length of the vertical portion. The T-tube has been made of the usual red rubber, also of pure gum and synthetic rubber.* The original long T-tube described by the author had horizontal limbs of unequal lengths—2 inches and 4 inches. Because of a problem in manufacture it was easier to join two equal lengths of tubing at the mid portion of one, making each end 6 inches. This is the type that has been used for several years. The proximal end can be cut to whatever length is needed. The synthetic rubber tubes are the most practical since they are somewhat rigid and are passed more easily through the ampulla. Sizes 12, 14, 16 and 18 are available (Fig. 267). The lumen of these tubes is sufficiently large to permit the free flow of bile into the duodenum.

Theoretical objections to placing a tube through the ampulla for varying periods of time must be considered. Reflux of duodenal content into the biliary duct system is a possibility. A large experience with the use of a long T-tube through the papilla has failed to demonstrate the occurrence of this possible complication. With the long T-tube through the papilla if barium is given by mouth, reflux within the duct system is rarely observed. Patients with a long T-tube in place do not have attacks of cholangitis even though the tube is left in place for a year or more. Cholangitis may be considered to have taken place

* These tubes are manufactured by the Davol Rubber Company, Providence, Rhode Island.

when transient jaundice has occurred but can be shown to be due to obstruction by sediment. The greater pressure within the biliary tract is probably sufficient to protect against reflux of the duodenal contents. Furthermore, the fact that the end of the T-tube within the duodenum passes close to the ligament of Treitz makes reflux less likely.

Exploration of the common duct should not be attempted through the cystic duct stump since it is impractical to probe the proximal duct system and it permits only demonstration of patency of the duct and the papilla. A generous incision should be made in the common duct itself, usually just distal to the entrance to the cystic duct. It is preferable to have the lower end of the incision stop at least 1 cm. away from the edge of the duodenum. With probes, stone forceps and scoops, the patency of the duct is demonstrated and stones removed. If one fails to pass a probe through the papilla, it is well to incise the peritoneum on the right of the duodenum, turning over the duodenum and raising the head of the pancreas. This may permit probing through the papilla when it was not possible previously, by straightening out the common duct. Dilatation with the Bakes dilators up to size 8 or 9 (Fig. 268) usually can be accomplished without undue difficulty and with minimal trauma.

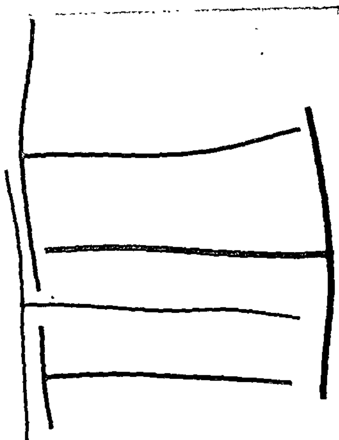


Fig. 267. Long T-tubes, sizes 12, 14 and 18. For comparison the conventional T-tube is shown below.

If patency of the papilla cannot be demonstrated by means of probes, it is necessary to open the duodenum. With elevation of the duodenum and head of the pancreas, the papilla can frequently be palpated directly by pressing the

amesenteric surface of the duodenum against the head of the pancreas. A longitudinal incision in the duodenum should be made well down in the second portion of the duodenum (Fig. 269). The posterior wall of the duodenum may be visualized and elevated by means of Allis clamps, bringing the ampullar region into view. A probe can then be passed down the common duct through the choledochostomy incision to the papilla, which can then be incised, per-

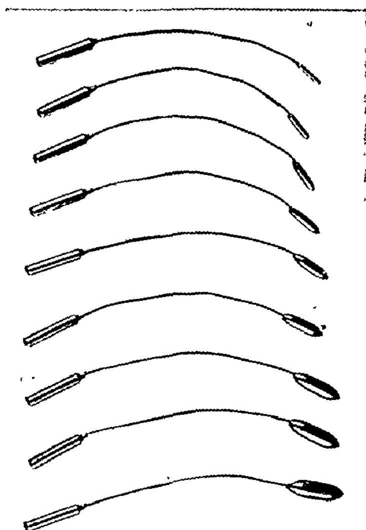


Fig. 268. Graduated Bakes dilators. These have flexible shafts so that the curves can be adjusted for convenience. They are most useful in probing and dilating the ampulla.

mitting passage of the probe. This can be followed by dilatation with the Bakes dilators from above downward under direct vision, or a right angle clamp can be put into the opening of the common duct and the sphincter of Oddi directly incised under vision (Fig. 269). A uterine probe or small Bakes dilator can then be passed through the papilla into the common duct and a long limb of the T-tube anchored on the probe and drawn through the papilla (Fig. 270). To avoid narrowing of the duodenum, the duodenal incision can be closed transversely (Fig. 270)

Failure to pass a probe through the papilla of Vater during common duct

exploration will usually result in subsequent obstructive symptoms, making secondary operation on the ducts mandatory. We have had a number of experiences of this type so that it has been necessary to resort to transduodenal exploration in a number of cases to avoid this postoperative complication.

If a long T-tube has been employed it requires care to avoid incrustations and blocking of the tube. Clamping of the vertical limb of the T-tube is not necessary except as a convenience during the time the patient is ambulatory.

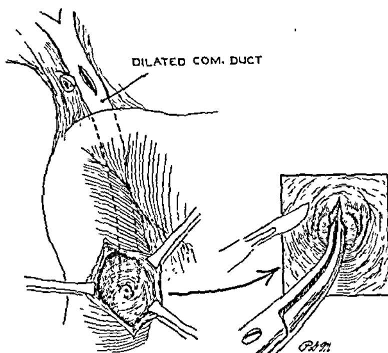


Fig. 269. Diagram illustrating transduodenal division and dilatation of the sphincter of Oddi. The gallbladder has been removed and the cystic duct tied. An incision has been made in the common duct but a probe failed to pass through the ampulla into the duodenum. A longitudinal incision on the anterior wall of the second portion of the duodenum is shown, exposing the papilla.

The inset shows division of the sphincter of Oddi following which dilatation with a clamp or with the Bakes dilators is performed.

Even when the tube is not clamped, the bile passes directly into the intestinal tract, with only a small amount of bile being discharged through the vertical limb. The tube should be irrigated twice a day after the first week postoperatively for the entire time that it is left in place. It can be permitted to drain at night during the hospital stay but need not be left open subsequent to this period. During the immediate postoperative period alimentation can be carried out with normal saline or 5 per cent glucose solution unless a severe degree of cholangitis is present. In this way, intravenous fluids may not be necessary. In addition to irrigation, a cholagogue or cholanteric in the form of decholin or bile salts should be given.

The time of removal of the long T-tube is determined by the pathologic change present at the time of operation. Rarely will it be removed in less than one to two months and frequently it is left in place for six, twelve or eighteen months. Irrigations of the T-tube are continued twice a day during this period.

Visualization of the biliary tract by injection of a radiopaque solution is not necessary (Fig. 271) and is not effective since the material will pass directly into the duodenum. It will, however, demonstrate incrustation of proximal or distal limbs. Removal of the long T-tube is no more difficult than removal of

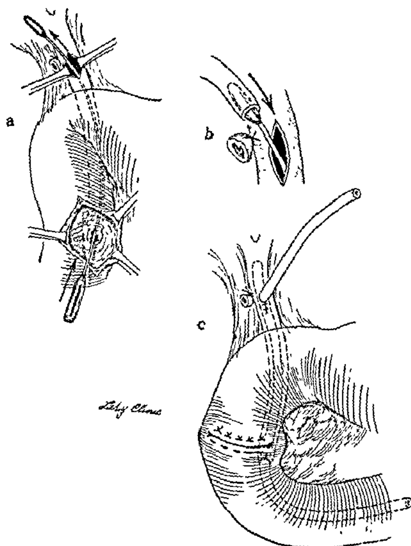


Fig. 270 *a*, A size 4 Bakes dilator has been passed through the dilated papilla and emerges from the opening in the common bile duct.

b, The long limb of the T-tube has been inserted over the probe for ease in drawing it through the papilla of Vater.

c, The long T-tube is now in place The incision in the common duct has been closed and the incision on the anterior wall of the duodenum has been closed transversely. This tube will be left in for a minimum of six months.

one with a short limb. After removal, irrespective of the length of time it has been in place, drainage of bile from the wound ceases within a few hours.

INDICATIONS FOR THE USE OF THE LONG T-TUBE

1. **Recurrent Common Duct Stones.** Stones may be found in the common bile ducts following previous operations on the biliary tract. The number of these cases will be in proportion to the frequency of common duct exploration at the original procedure While stones may be left in the hepatic ducts

where they have floated back in the bile, they are usually encountered in the ampullar region. From the physical characteristics of these stones, most of them unquestionably have formed in the gallbladder and have been left in the duct system. Others unquestionably form in the duct itself and in these circumstances some degree of obstruction in the distal duct can be demonstrated. Re-exploration of the duct must be done in these cases and the long T-tube is particularly useful. The stones are cleared from the duct system and the papilla



Fig 271. Cholangiogram of a size 14 long T-tube. Moderate blunting of the intrahepatic biliary ducts remains as demonstrated with injection of lipiodol. The distal limb passes through the ampulla and can be seen within the lumen of the duodenum.

dilated if probes can be readily passed through. Repeated irrigations of the proximal duct system will get rid of sediment and sand. Small stones or fragments of stones will be pushed through the dilated ampulla by irrigation of the distal duct. If satisfactory dilatation of the ampulla cannot be effected, a transduodenal approach to the ampulla must be used. In all of these cases the long T-tube should be implanted and left in place for six to twelve months. During this time irrigation of the tube two or three times a day is important and will be helpful in clearing the intrahepatic radicles of sediment.

2. **Fibrosis of the Ampulla of Vater.** While more patients are being found with symptoms persisting after cholecystectomy, or after cholecystectomy and choledochostomy, these symptoms may persist without jaundice due to nar-

rowing in the region of the papilla of Vater. Diagnostic biliary drainage may show indifferent findings or may show bilirubin pigment and cholesterin crystals when stones are present. Many of the cases considered as biliary dyskinesia are in reality cases of organic obstruction in the ampullary region. Dilatation and implantation of the long T-tube with or without transduodenal exploration will relieve the symptoms in these cases. The T-tube should be left in place for a minimum of six months and frequently for twelve months. In our experience, some of these patients have had multiple operations on the biliary tract without relief of symptoms, and the good results following the employment of the long T-tube are very gratifying.

3. **Repair of Benign Strictures.** Successful repair of benign strictures is dependent upon accurate anastomosis of the proximal and distal portions of the duct system. The results following such repair are much better in our experience than after anastomosis of the proximal duct to some portion of the gastrointestinal tract. In view of the fact that the ampulla has been functionless during the duration of the stricture, it may become narrowed and fibrosed. Even with dilatation it may be necessary to have a mold not only through the repair of the strictured area but also through the duct entrance into the duodenum. We have had several patients in whom incrustations have developed in the conventional short T-tube or plugging of other indwelling tubes, such as vitallium, rubber or bouncing clay, accompanied by stone formation proximal to the indwelling tube. If the long T-tube can be employed in end-to-end duct repair of the stricture, bringing the vertical limb through a normal portion of the duct either proximal or distal to the anastomosis, and with the long horizontal limb passing through the duodenum, this incrustation or stone formation may be avoided. Such a T-tube should be left in place for a minimum of one year or longer, continuing irrigations throughout the entire period.

4. **Malignancy of the Bile Ducts.** Malignancy at the lower end of the common duct is best treated by radical pancreatoduodenal resection, with anastomosis of the proximal duct to the jejunum. Occasionally, carcinoma is encountered within the hepatic ducts or common duct that cannot be resected because of extension. Under these circumstances we have employed the long T-tube after dilatation of the malignant area to maintain an open passage through the malignancy so that bile passes directly into the duodenum. While the results are discouraging in these cases, at least it serves during the short period of life to relieve the jaundice without the production of an external biliary fistula, with resultant loss of bile. Even advanced cases involving the gastrohepatic omentum may be treated in this fashion, although the relief is quite temporary.

5. **Resection for Duodenal Ulcer.** The long T-tube may be quite useful in certain gastroduodenal resections for duodenal ulcers. The largest group of patients with duodenal ulcers requiring surgical intervention are those in whom the ulcers are penetrating or perforating into the pancreas in the posterior portion of the first and upper second portions of the duodenum. Before resection can be demonstrated to be feasible and safe in an appreciable number of these, the common duct should be identified, opened and its intrapancreatic course determined. Implantation of the long T-tube permits careful dissection of the duodenum and its later closure without interference with the lumen of the com-

mon duct. In these cases the T-tube may be removed safely within twelve to fourteen days.

6. **Duodenal Diverticulum.** The same safety factor may be necessary in the resection of certain duodenal diverticula as for subtotal gastrectomy for duodenal ulcer. When they occur in the second portion of the duodenum their necks may be found near the course of the common bile duct. To be sure, these are few in number, but when there are symptoms demanding resection of a duodenal diverticulum in this area, it is quite helpful to know that the common duct is left intact by implanting a long T-tube through the papilla.

SUMMARY

The uses of the long T-tube in surgery of the biliary tract have been presented. An increasing number of patients has been encountered in the past ten years with obstruction of the biliary duct persisting after previous operation. Such unsatisfactory results may be avoided by recognizing the additional pathologic change at the original operation and utilizing the long T-tube with the distal limb passing through the papilla into the duodenum. Reflux into the biliary duct system with accompanying cholangitis as evidenced by malaise, chills, fever and jaundice is rare and is no contraindication to the use of the long T-tube. Indications for the use of the long T-tube are outlined. It should be emphasized that the tube requires irrigation throughout the time that it remains in place. During the immediate postoperative period alimentation can be utilized, decreasing the amount of intravenous therapy.

Experiences over a ten-year period demonstrate that the results after biliary tract surgery may be improved by the use of the long T-tube in selected cases.

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rowing in the region of the papilla of Vater. Diagnostic biliary drainage may show indifferent findings or may show bilirubin pigment and cholesterin crystals when stones are present. Many of the cases considered as biliary dyskinesia are in reality cases of organic obstruction in the ampullary region. Dilatation and implantation of the long T-tube with or without transduodenal exploration will relieve the symptoms in these cases. The T-tube should be left in place for a minimum of six months and frequently for twelve months. In our experience, some of these patients have had multiple operations on the biliary tract without relief of symptoms, and the good results following the employment of the long T-tube are very gratifying.

3. **Repair of Benign Strictures.** Successful repair of benign strictures is dependent upon accurate anastomosis of the proximal and distal portions of the duct system. The results following such repair are much better in our experience than after anastomosis of the proximal duct to some portion of the gastrointestinal tract. In view of the fact that the ampulla has been functionless during the duration of the stricture, it may become narrowed and fibrosed. Even with dilatation it may be necessary to have a mold not only through the repair of the strictured area but also through the duct entrance into the duodenum. We have had several patients in whom incrustations have developed in the conventional short T-tube or plugging of other indwelling tubes, such as vitallium, rubber or bouncing clay, accompanied by stone formation proximal to the indwelling tube. If the long T-tube can be employed in end-to-end duct repair of the stricture, bringing the vertical limb through a normal portion of the duct either proximal or distal to the anastomosis, and with the long horizontal limb passing through the duodenum, this incrustation or stone formation may be avoided. Such a T-tube should be left in place for a minimum of one year or longer, continuing irrigations throughout the entire period.

4. **Malignancy of the Bile Ducts.** Malignancy at the lower end of the common duct is best treated by radical pancreatoduodenal resection, with anastomosis of the proximal duct to the jejunum. Occasionally, carcinoma is encountered within the hepatic ducts or common duct that cannot be resected because of extension. Under these circumstances we have employed the long T-tube after dilatation of the malignant area to maintain an open passage through the malignancy so that bile passes directly into the duodenum. While the results are discouraging in these cases, at least it serves during the short period of life to relieve the jaundice without the production of an external biliary fistula, with resultant loss of bile. Even advanced cases involving the gastrohepatic omentum may be treated in this fashion, although the relief is quite temporary.

5. **Resection for Duodenal Ulcer.** The long T-tube may be quite useful in certain gastroduodenal resections for duodenal ulcers. The largest group of patients with duodenal ulcers requiring surgical intervention are those in whom the ulcers are penetrating or perforating into the pancreas in the posterior portion of the first and upper second portions of the duodenum. Before resection can be demonstrated to be feasible and safe in an appreciable number of these, the common duct should be identified, opened and its intrapancreatic course determined. Implantation of the long T-tube permits careful dissection of the duodenum and its later closure without interference with the lumen of the com-

mon duct. In these cases the T-tube may be removed safely within twelve to fourteen days.

6. **Duodenal Diverticulum.** The same safety factor may be necessary in the resection of certain duodenal diverticula as for subtotal gastrectomy for duodenal ulcer. When they occur in the second portion of the duodenum their necks may be found near the course of the common bile duct. To be sure, these are few in number, but when there are symptoms demanding resection of a duodenal diverticulum in this area, it is quite helpful to know that the common duct is left intact by implanting a long T-tube through the papilla.

SUMMARY

The uses of the long T-tube in surgery of the biliary tract have been presented. An increasing number of patients has been encountered in the past ten years with obstruction of the biliary duct persisting after previous operation. Such unsatisfactory results may be avoided by recognizing the additional pathologic change at the original operation and utilizing the long T-tube with the distal limb passing through the papilla into the duodenum. Reflux into the biliary duct system with accompanying cholangitis as evidenced by malaise, chills, fever and jaundice is rare and is no contraindication to the use of the long T-tube. Indications for the use of the long T-tube are outlined. It should be emphasized that the tube requires irrigation throughout the time that it remains in place. During the immediate postoperative period alimentation can be utilized, decreasing the amount of intravenous therapy.

Experiences over a ten-year period demonstrate that the results after biliary tract surgery may be improved by the use of the long T-tube in selected cases.

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EXPERIENCE WITH THE OPERATIVE MANAGEMENT OF 280 STRICTURES OF THE BILE DUCTS

With a Description of a New Method and a Complete Follow-up Study of the End Results in 229 of the Cases

FRANK H. LAHEY AND LUDWIG J. PYRTEK

With almost no exceptions, injuries to the bile ducts occurring in the course of operations for gallstones are avoidable by following a few not too complicated rules which will be spoken of and illustrated later in this paper. When injuries to the bile ducts have taken place they present one of the most difficult surgical problems that confront the surgeon and one of the most difficult in which to obtain a satisfactory and lasting result. It is unfortunate that when the accident of a bile duct injury occurs, it is often in a patient who is otherwise well, usually not too advanced in years and who, were it not for the duct injury, would have the same prospect of length of life and good health as would a normal, well person.

When an injury to the bile duct has occurred the prospect of life for the individual in whom it has occurred is definitely shortened and the prospect of the frequent appearance of undesirable complications, such as chills, fever, and jaundice, is rendered extremely probable.

In writing on this subject previously those of us in this clinic who have dealt with these strictures have stressed that duct injuries in the course of operations upon the gallbladder and bile ducts are the result of three types of accidents: hemorrhage from the cystic or hepatic arteries, confusion concerning the anatomy at the junction of the cystic, common, and hepatic ducts, or the presence of anomalous ducts or vessels causing uncertainty concerning the anatomical relationships between the ducts and the vessels in this region.

Cholelithiasis is a common disease, producing not infrequently symptoms of such urgent character as to make surgery the only means of relieving the patient.* Cholecystectomy has so properly superseded cholecystostomy as the operative procedure to be applied to the patient with gallstones that cholecystostomy has largely been abandoned, with the result that enormous numbers of cholecystectomies are being done every year all over the world. It is to be remembered that each time a cholecystectomy is done there is a real danger of injury to the bile ducts or hepatic artery, with the consequent possibility of producing in the patient concerned invalidism, shortening of life, or an operative fatality. It is for these reasons that we wish to discuss why such injuries occur, how they can be avoided, the various plans which we have employed and the changes

Originally published in Surgery, Gynecology and Obstetrics, 91 25–56 (July) 1950.

* In 1,029 patients operated upon for gallstones, 93.2 per cent complained of pain.

we have made in dealing with patients who have strictures of the ducts, and to present a new technical concept (Fig. 296) concerning their management which was developed by R. B. Cattell and one of us (F.H.L.).

In the Lahey Clinic we have now operated upon 280 patients for stricture or destruction of the bile ducts. Some of these (41) have been of such recent date as to make their study not worth while. Therefore, of all cases done up to 1949, 239 have been studied. Ten patients could not be traced and so a complete follow-up study of 229 patients operated upon for duct destruction or stricture is presented. Each group is separated into the type of operation used; the results are reported as excellent, good, and unsatisfactory, and mortality rates are given.

TYPES OF DUCT INJURY

For practical purposes, only two types of duct injury occur at the time of a surgical operation upon the gallbladder or bile ducts: crushing of the duct by grasping it with a clamp (Fig. 277) or the excision of part of the duct—com-

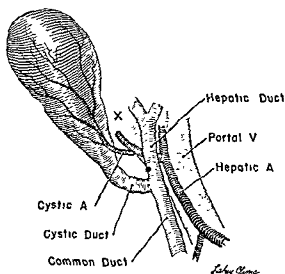


Fig. 272. Note in this illustration when hemorrhage from the cystic artery has occurred how easily the common hepatic duct may be caught when a clamp is put on blindly. Note the point marked *X* through which the finger is inserted in the method of removing the gallbladder in the presence of acute cholecystitis. (See Figs. 273 and 274.) Note also the danger to the cystic artery if the finger is inserted too low in the mesentery of the gallbladder.

mon, common and hepatic, hepatic or sections of anomalous hepatic ducts. These two types of injury vary only in the level at which they occur between the point where the common bile duct disappears behind the duodenum and the point where the hepatic duct or ducts enter the liver. The portion of the common duct which passes through the head of the pancreas and behind the duodenum is so well protected here anatomically that it is rarely injured. It is by taking advantage of this point that the operative plan of repair which will be described and illustrated later in this paper (Fig. 286) has been developed.

Most of the crush injuries to the bile ducts are related to hemorrhages either from the cystic or the right hepatic artery and attempts to control such hemorrhage without clear visualization of the anatomical structures because they are

obscured by the profuse hemorrhage at the depth of a deep cavity and because of the difficulty of keeping the blood sponged out so that the bleeding part can be clearly visualized and controlled.

In many of the patients upon whom we have operated for bile duct strictures, a review of description of the original operation, a copy of which we have often obtained from the hospital where the original operation was done, has

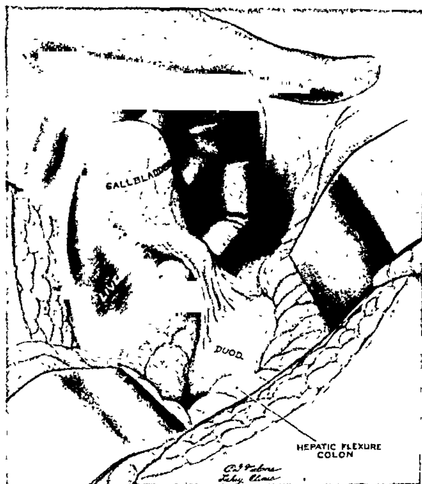


Fig. 273. In this illustration is shown the method of inserting the finger through the mesentery of the gallbladder in cholecystectomy for acute and subacute cholecystitis. Note that the finger is inserted close to the liver to avoid the cystic artery, as shown in Figure 272.

often revealed that serious bleeding was encountered and frequently controlled during the operation only by the application of a clamp which in several instances was left in place to be removed three or four days later.

If one will observe Figure 277, *a* and *b*, the explanation of the crush type of stricture is obvious. It will be seen that the right hepatic artery from which the cystic artery arises usually runs parallel with the hepatic duct which from above downward is just inferior to it and passes under or over the duct. It will be seen that the cystic artery, coming off as it normally does when not in an anomalous position, from the right hepatic artery, as it courses to the gallbladder across the angle made by the junction of the hepatic with the cystic duct, is shorter than the cystic duct. It will be noted in Figure 272, also, that if the gallbladder is removed from above downward, as it so frequently is in acute cholecystitis,

and traction is then made upon the mobilized gallbladder, the traction will be almost entirely upon the cystic artery. With continued traction, the cystic artery will tear and not infrequently directly at its point of origin from the right hepatic artery. This will result in a vigorous type of bleeding since the hepatic artery or its righ
of blood in a



Fig. 274. In this illustration is shown how readily the finger passes behind the gallbladder in the layer between the gallbladder wall and the fascia layer over the liver. In the inset is shown the method of turning the gallbladder to the left and the ability with this exposure to demonstrate the common duct, hepatic duct, cystic duct and the cystic artery, which may be clamped before removal.

rhage is in the depth of a deep wound and if there are not good exposure and good relaxation, there can be great difficulty in visualizing the point of origin of the hemorrhage and accurately controlling it.

Such an emergency can be avoided by careful dissection of the cystic artery before the cystic duct is clamped and cut, by taking great care not to make traction upon the mobilized gallbladder either when it is removed from above downward or by making traction on the ampulla of the gallbladder when it is removed from below upward. It has been a principle which has been religiously followed in this clinic that never must a cystic duct be clamped and cut until the cystic artery has been found and divided; the possibility of the

of this type of hemorrhage by the undue traction on the artery may be thus avoided.

In Figures 273 and 274 is shown a safe method of dealing with cholecystectomy in acute and subacute gallbladders. It will be noted in Figure 273 that the index finger has been inserted through the mesentery made by the edematous tissue between the cystic duct, the hepatic duct and above the cystic artery as it comes off the right branch of the hepatic artery. By inserting one's finger gently through this edematous mesenteric region close to the bed of the liver, a line of cleavage can be definitely established between the gallbladder and the fibrous bed of the gallbladder in the liver. In Figure 274 is shown the continuation of the separation of the line of cleavage between the edematous gallbladder and the bed of the liver as the finger is carried upward toward the edge of



Fig. 275. In this illustration is shown the method of controlling bleeding from the cystic artery, shown by the arrow, by means of putting the index finger in the foramen of Winslow and the thumb over the hepatic artery.

the liver. This has proved a very safe and rapid way of removing the subacute gallbladder. It is important, however, in performing this procedure to be certain that the finger as it is inserted through the edematous mesentery is close to the bed of the liver and does not tear the cystic artery as it comes off the right branch of the hepatic artery. This accident will occur if the finger is inserted through this edematous membrane too close to the point of entrance of the cystic duct into the common and hepatic ducts. In the inset in Figure 274 is shown the ability in the acute and subacute gallbladder, by turning the gallbladder toward the left, to visualize the anatomy and to wipe out the cystic artery, the hepatic duct, the cystic duct and, in many cases, the arching right hepatic artery. This has proved a safe and valuable method to deal with cholecystectomies for acute and subacute gallbladders and one which by tipping the gallbladder to the left after it has been freed from the bed of the liver, has made the anatomical exposure of the structures, even when the tissues are edematous and indurated, much safer than if an attempt were made to do this operation from below upward.

In Figure 275 is shown the well known procedure which makes the manage-

ment of hemorrhage of the cystic or right hepatic artery relatively simple should accidental injury to these vessels occur, as will be inevitable in occasional cases. It is to be noted that if such a hemorrhage occurs, one may introduce the index finger into the foramen of Winslow, the thumb then palpates the hepatic artery just above the common duct and it is compressed between the thumb and finger. This compression controls bleeding, the clot may be wiped out, the field may then be well exposed by wide retraction, the thumb can be released, the bleeding permitted to occur momentarily, the field again wiped dry, and thus the bleeding point accurately picked up without injury either to the hepatic artery if the hemorrhage is from the cystic artery, or to the underlying right branch of the hepatic artery. The vessel can then be accurately tied with silk and the situation has then been completely controlled without injury to the duct. That when the right hepatic artery is ligated, partial atrophy of the right lobe of the liver occurs together with compensatory hypertrophy of the left lobe was suggested by such an occurrence in a recent case in which such an accident had taken place and these conditions could be demonstrated when an operation for duct repair was being done.

A much less common type of duct injury is that in which an entire section of common and hepatic duct is cut away as the result of so lifting upon the gallbladder that a clamp supposedly applied to the cystic duct is applied to the angulated or peaked common and hepatic ducts.

Injuries other than these are most commonly the result of the occurrence of anomalous anatomical arrangements, such as double right hepatic ducts, cystic ducts entering the right hepatic duct and cystic ducts passing beneath the duodenum and entering the common duct at some point behind the duodenum and anomalous arterial supply to the liver and gallbladder. All of the accidents of this character can be avoided by wide exposure, dry field, good light, and such accurate anatomical demonstration of the bile passages, common, cystic and hepatic ducts, hepatic artery, and cystic artery that any anomalies are clearly recognized.

In previously writing upon this subject one of us (F.H.L.[6]) laid down a simple set of rules which, if followed, will avoid the occurrence of any and all of the aforementioned accidents. They consist of good relaxation, best accomplished by means of spinal anesthesia or the use of curare with a general anesthetic agent, and long incisions in order to obtain adequate exposure. When one balances the dangers and hazards of inadequate exposure and the possibilities of the production of these sometimes fatal and often crippling complications against 3 or 4 extra inches of an abdominal incision, the side on which advantage rests is at once obvious.

In addition to adequate relaxation and long incision, we wish again to call attention to the plan which we have previously described of obtaining exposure of these important anatomical structures—the common duct, the hepatic duct, the cystic duct, the hepatic artery and the cystic artery (Fig. 276). Exposure of these structures can be obtained most satisfactorily by mobilization of the hepatic flexure and the duodenum to the left and by retraction of the liver to the right. It is to be recalled anatomically that the normal position of the common and hepatic ducts is a lax one, that normally, owing to the laxity of the

common and hepatic ducts, the aperture into the lesser peritoneal cavity at the foramen of Winslow does not gape but is collapsed. With the duodenum and the hepatic flexure retracted to the left and the liver to the right, it is possible as shown in Figure 276, so to put the hepatic duct and the common duct upon the stretch that the opening into the lesser peritoneal cavity at the foramen of

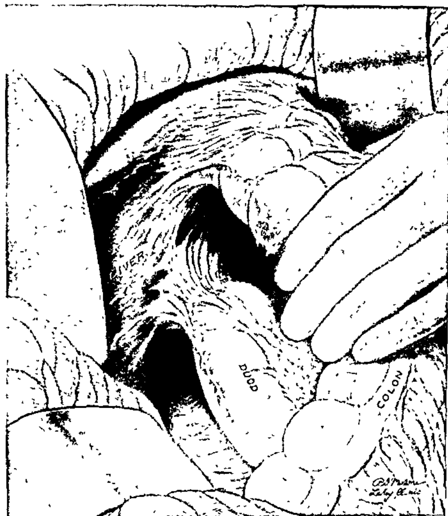


Fig. 276. In this illustration is shown the method which we have previously described of obtaining exposure of the region of the common and hepatic ducts in patients who have had several previous operations upon their gallbladders. Note that the hepatic flexure has been mobilized from the lower edge of the liver and rotated to the left until the duodenum, usually adherent to the hilum of the liver at the point where previous surgery has been done upon the ducts, is visualized. The duodenum can now be so mobilized that all of the duct structures can be brought out.

Winslow gapes widely and is made completely visible, so visible that in these patients the vena cava on its posterior aspect becomes clearly demonstrable. With this type of retraction and exposure, the duct structures which must be dealt with, together with the cystic artery and hepatic arteries, can be plainly seen even in fat individuals. All anatomy can be demonstrated, the cystic artery can be found and clamped under clear and direct vision, and the point of junction of the cystic duct with the common and hepatic ducts clearly demonstrated. Not only does this exposure make it possible to deal with these structures, cystic

duct, common duct, hepatic duct and cystic artery, with safety but, in addition, the anatomy is so plainly visualized at this point of junction of the cystic duct with the common and hepatic ducts that accessory bile ducts can often be plainly recognized, clamped and tied, thus avoiding the discharge of bile which frequently occurs after operation when gallbladders are removed without this exposure and unrecognized accessory ducts are torn away.

Without these exposures we would never have felt justified in making so many investigations of common ducts, 44 per cent, in patients having cholecystectomy as we have over the years; without such exposure we would have faced the risk of producing duct injuries, such as strictures and biliary fistulas.

The history associated with these injuries is usually related to the type of injury. In those patients in whom there is uncontrollable bleeding from the cystic artery or hepatic artery and in whom the hepatic duct has been crushed by a clamp applied to control bleeding, the appearance of obstructive biliary symptoms is delayed. In the cases in which the clamp, as is often the case, has been put on blindly deep in the field in a last desperate attempt to control bleeding, there is frequently no discharge of bile or jaundice following the removal of the clamp at the end of four to five days because, upon removal of the clamp; the crushed duct expands and does not immediately produce an obstruction. It is in these cases that, as a result of the crush, narrowing of the duct as a result of fibrosis takes place usually three to four months after the injury, with recurring attacks of jaundice, chills, and fever at that delayed time and not immediately after the injury.

When there has been such an accident and when, three to four months after the patient has left the hospital, there is a history of recurring attacks of jaundice, chills and fever, or even jaundice alone, one should be suspicious that this condition is the result of fibrotic narrowing of the duct at the point where the crush occurred.

In other cases, particularly those in which sections of the duct have been taken out or anomalous ducts have been cut, there will be immediate discharge of bile following the operation and the continued discharge of bile for an indefinite period.

An event which has occurred in almost all of our cases of this type is that after a considerable period of time the external biliary fistula closes spontaneously, the patient becomes jaundiced and the stools acholic. Shortly after this the jaundice spontaneously disappears, the stools become normally colored and the patient feels well. This represents the occurrence of a spontaneous internal biliary fistula due to the rupture of the dilated hepatic duct into the adjacent duodenum to which it usually becomes adherent. There may be rare cases in which this spontaneous fistula remains permanently patent but such has not been the case in dealing with those 280 patients with strictures of the duct upon whom we have operated. In practically every case in which we have attempted these bile duct repairs a fistula into the duodenum has been found but by the time the patient has come to us for duct repair the fistula has in nearly every case so contracted down that almost no bile is passing through it.

In a patient who has had an injury to the bile duct and in whom repair has been attempted, complete and uninterrupted successful restoration of bile flow

into the intestine is to be assumed only when the external biliary fistula closes completely and the patient remains free for over a year from the appearance and persistence of jaundice or the occurrence of skin itching, increased bilirubin, chills and fever.

The *prospect of a good surgical result in all operations* for the repair of injuries to the bile ducts will depend upon which type of injury (crush or excision) to the bile duct has taken place, whether or not previous attempts have been made

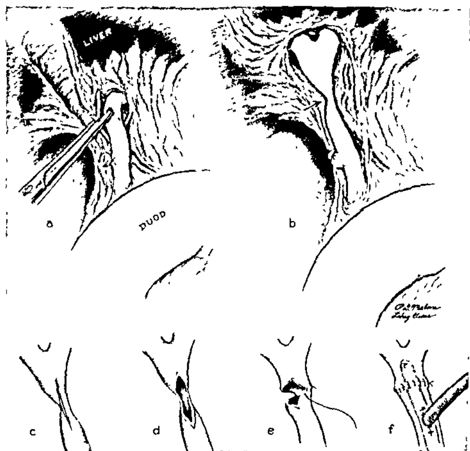


Fig. 277. This illustration demonstrates how the crush type of injury to the hepatic duct occurs. Note in *a*, the diagrammatic illustration of a clamp grasping the cystic artery, the right branch of the hepatic artery and at the tip including the hepatic duct. In *b*, note the short and local stricture which results from this type of injury. In *c*, *d*, and *e*, the Heineke-Mikulicz type of repair. Note in *f*, the principle which Lahey has described of placing the T-tube through a separate incision in order that it does not have to be withdrawn through the suture line.

to repair the resulting stricture, how soon after the injury the repair of the duct is attempted, and whether or not, as the result of long delay and repeated failures to repair the stricture successfully, cirrhosis has resulted because of irreparable liver damage from the biliary obstruction and repeated attacks of biliary infection so frequently associated with these failures.

The best results in operations for repair of the bile ducts will be obtained in those patients with crush injuries of the duct and with the remaining portions of the ducts intact. Most of these injuries will result in but short strictures of the duct as shown in Figure 277, and because of the short section of the duct injured, will lend themselves to plastic repair (Heineke-Mikulicz type) as

illustrated in Figure 277 (end-results—100 per cent good—in this type of repair are given in Table 8) or to excision of the strictured area, mobilization of the lower end of the common duct from its place behind the duodenum in the head of the pancreas, as practiced in this new concept of duct repair later to be described, and accurate mucosa-to-mucosa suture of the ducts by end-to-end anastomosis, shown in Figure 286.

The next best results will be obtained in those cases in which short portions of the duct have been accidentally excised in the course of the cholecystectomy in which it has been possible to undertake the repair by end-to-end anastomosis

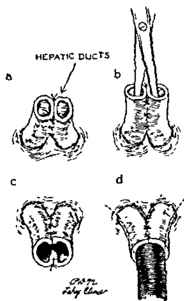


Fig. 278. In this illustration may be seen the complete loss of the common hepatic duct with only, as shown in *a*, the two separate right and left hepatic ducts. This illustrates the plan devised by Cattell, of this clinic, of converting the right and left hepatic ducts into one common hepatic duct and the introduction of a Y-tube into them for anastomosis of the common duct to them.

within a few days of the time of injury and in which no previous attempt to repair the injury has been made.

The poorest results will be obtained in those cases in which several unsuccessful attempts have already been made to repair the injured duct.

If we have learned anything from this large experience with operations for the repair of bile duct injuries it is that every time an unsuccessful attempt is made to repair an injured bile duct there will be loss of duct structures and most frequently and unfortunately loss of hepatic duct structure, and as the result of this, greater and greater difficulty in fulfilling the fundamental requirement of our concept of the most successful way to repair duct strictures or defects, that is, mobilizing the lower end of the common duct from the head of the pancreas, suturing the ends of the mobilized ducts accurately together by mucosa-to-mucosa end-to-end anastomosis, and leaving for a period of up to one year an indwelling T-tube placed below or above the suture line to support the suture and insure patency. The leaving in for a year of one limb of a supporting T-tube through the suture line of the anastomosed duct and intro-

duced through an incision in the duct either above or below the line of anastomosis as proposed by Lahey is an extremely important step in this operating plan since in many of these cases the ducts are scarred, the suture difficult, and the anastomosis at times not as meticulously accurate as one could want it to be.

Following repeated unsuccessful previous reparative operations upon the bile ducts, as has been true in many of the cases coming to us for repair, the only portions of the hepatic ducts which frequently remain intact in such patients will be the two limbs of the hepatic duct which are intrahepatic (Fig. 278). All



Fig. 279. Roentgenogram of such a case of direct anastomosis of a mobilized common duct to two hepatic ducts which have been converted into one by the procedure devised by Cattell.

too often following these repeated attempts elsewhere at bile duct repairs we have found in our attempts to accomplish repair in them that all of the extrahepatic duct which then remains as a single duct structure will have been destroyed. The hepatic duct portion of the biliary duct tract will then be represented only by the separated two main intrahepatic divisions of the hepatic ducts, to which end-to-end anastomosis of the mobilized single common duct is impossible. It is to be recalled that the ingenious operation devised by Longmire of anastomosis of the left lobe of the liver and left bile duct in it to the jejunum will not be ideally applicable here since, with no common hepatic duct, there will be no communication between the right and left lobes of the liver. It is in these cases that the only procedure left to employ is a "Y" tube made of plastic material called bouncing clay and with the Y ends of the tube introduced into

the hepatic ducts and into the mobilized end of the common or hepatic duct or into the jejunum or duodenum or the use of a T-tube with a Y end as shown in Figure 279.

Recently, Cattell (Fig. 278) of this clinic has devised an ingenious plan of repair of cases of this type. Following his suggestion Lahey also made use of this plan in one of the cases in which there was no common hepatic duct and only the two separated intrahepatic ducts entirely within the liver, and found it of great aid in managing these difficult cases.

After dissecting the intrahepatic ducts out of the substance of the hilum of the liver with the fulgurating loop and with blunt scissors, the two ducts are



Fig. 280. Note in this illustration the T-tube devised by Lahey, the two limbs of which going into the right and left hepatic ducts are half caliber tubes so that they can be readily passed through the short stump of [illegible]
obvious in dealing with this type of [illegible]
through the stump of the common [illegible]
but when they are of half caliber, when brought in approximation, they represent only the caliber of a single tube and can then be passed through the common duct marked X-2 (Fig. 281) and each then guided into the left and right hepatic ducts.

brought together by catgut sutures and the two attached walls cut to convert them into a single common canal. One of the limbs of a T-tube is then cut, as shown in Figure 278, and one limb placed up one duct, the other up the other hepatic duct after the T-tube has been placed in the common duct which has been mobilized and brought up for suture to the end of the two hepatic ducts now made into one.

Lahey has recently devised a tube (Fig. 280) for introduction into the intrahepatic ducts and with the long limb passing down the anastomosed common duct as shown in Figure 281.

We have operated upon many patients with injuries and strictures of the bile ducts after they have had three, four, five, and recently one with seven and one with eight previous attempts at repair, and we feel safe in saying that with each unsuccessful attempt at duct repair the changes for a satisfactory and lasting outcome progressively diminish. Lest surgeons dealing with this type of operation be unduly intimidated by cases in which have been made several unsuccessful attempts at repair, we would state one of our most successful results

following the use of the new plan here suggested was in a patient who had had seven unsuccessful attempts at repair before coming to us.

In an editorial[5] on this subject published in *Surgery, Gynecology and Obstetrics,* Lahey, with great reluctance lest it be misunderstood, urged that everyone undertaking repair of an injured duct should realize that whoever undertakes the first duct repair will have the best chance to obtain a lasting and satisfactory result, that with each failure the chances of a successful outcome are markedly diminished. The operative procedure which offers real hope of

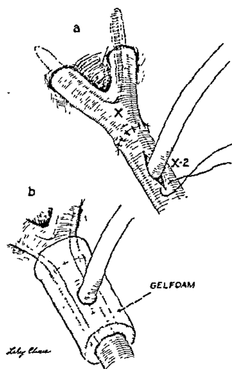


FIG. 281. *a,* In this illustration is shown the method of doing a direct end-to-end anastomosis of the common duct to a short stump of hepatic duct and the use of the tube devised by Lahey and shown in Figure 280. In *b,* is shown diagrammatically the method of wrapping the anastomosis up in gelfoam to discourage bile leakage. Note again the method of introducing the Y-tube through a separate incision in the common duct (X-2) so that a complete circular anastomosis can be made and with no tube emerging through the suture line.

lasting and successful results and the one based upon logical surgical principles is mobilization of the lower end of the common duct and head of the pancreas so that accurate end-to-end anastomosis can be done. It is with these facts in mind that we suggested that one should seriously review his ability, equipment, and experience before undertaking repair of these injuries lest repair be made hopeless for the surgeon experienced with such cases when they are finally placed in his hands.

Again, that readers of this paper may not despair completely about these at times seemingly hopeless cases, we cite brief notes concerning 3 patients whose condition appeared quite hopeless but who have obtained quite satisfactory results, despite many previous operations.

CASE 1. A 34 year old golf professional was first seen at the clinic on June 29, 1943, with the following previous history. In 1933 a cholecystectomy and appendectomy

were performed elsewhere for jaundice. The gallbladder was found to be negative for stones. Following operation he had been quite constantly jaundiced and the jaundice had deepened. On December 7, 1942, a stricture of the common duct was repaired elsewhere; a T-tube was implanted and remained in place for three and one-half months. After its removal the jaundice and itching recurred.

When he came to the clinic a diagnosis of an incomplete stricture of the bile duct was made and he was admitted to the hospital on June 30, 1943. He was given preoperative care for one week and then submitted to surgery on July 7, 1943. A stricture was found 10 cm. proximal to the ampulla located at the hilum of the liver. The



FIG. 282. A vitallium tube is shown in place. Note the projecting tab and recall that in spite of this projecting tab some of these tubes have passed spontaneously through the common duct into the duodenum.

stricture was dilated to 7 mm. and a T-tube was inserted beyond the strictured portion with one limb of the T-tube passing through the stricture. His postoperative course was uneventful.

Because the jaundice did not disappear the patient was submitted to intensive study after which a diagnosis of congenital hemolytic anemia was made which was probably the cause of the jaundice for which he had his first operation. With the T-tube still in place, on December 14, 1943, a splenectomy was performed. During this same hospital admission a second operation was performed on the common duct, at which time a plastic repair of the common and hepatic ducts with the insertion of a straight vitallium tube was performed (Fig. 282). This was done because the T-tube had become obstructed by bile and stones. Following these operations his jaundice cleared completely for a brief period. His next visit to the clinic was in August, 1945, at which time he stated that from shortly after his last operation he had never been free of intermittent attacks of jaundice, with clay-colored stools. It was decided that his vital-

lium tube had become obstructed. On August 27, 1945, operation on the ducts was again performed, at which time the vitallium tube, which was obstructed with débris, was removed. A biliary fistula was noted between the bile duct and the duodenum. The vitallium tube was replaced by a T-tube with the long arm extending through the ampulla to the duodenum and the proximal arm above the stricture. A postoperative hemorrhage occurred and on September 3, 1945, he was returned to the operating room, at which time a branch of the gastroduodenal artery was ligated. This tube was left in place until October 15, 1945, and then removed by merely pulling on the external portion of the T-tube.

The patient was next seen at the clinic in October, 1946, at which time he was playing golf and only occasionally had pruritus. In June, 1947, he reported that he was having no pain, fever or chills, that he was well and on a rigid liver regimen. He reported again in October, 1947, after a mild attack of cholangitis. A letter was received February 23, 1949, at which time he was enjoying good health.

In summary this patient had had 7 surgical procedures of which 5 were on the biliary tract, 4 of which were for the repair of a stricture of the bile duct. In addition, he had had a splenectomy for a coincidental hemolytic anemia which, in all probability, was the cause of his original jaundice for which the original cholecystectomy had been done, and a final operation for intra-abdominal hemorrhage. This patient was reported recently to be quite well.

CASE 2. This patient had had a cholecystectomy in October, 1943, with an injury to her bile duct. She had had two previous repairs of her common duct elsewhere in 1943 and 1944. During the latter part of 1944 a T-tube was inserted, elsewhere, into the hepatic duct and the common duct. She managed to get along with the T-tube until 1947, when she again became jaundiced and was operated on again, with the insertion of another T-tube. This T-tube pulled its external part into the ducts and passed itself down the common duct and into the duodenum in three months. In January, 1948, another T-tube was inserted elsewhere, but in spite of this, it became blocked and the patient came to us for repair of her duct. (There had thus been 6 previous operations on the biliary tract before the patient came to the clinic and 7 previous operations on the gallbladder and ducts.)

On July 14, 1948, operation was performed. The common hepatic duct was found with almost no cuff remaining—that is, almost all the common hepatic duct had been destroyed—and a Y-tube was inserted into the two limbs of the hepatic duct with less than 1 cm. of hepatic duct remaining. To this the mobilized common duct, which was freed from the pancreas and from behind the duodenum, was anastomosed directly to the short cuff of remaining hepatic duct over a completely indwelling Y-tube of bouncing clay, with complete and satisfactory restoration of flow of bile into the intestinal tract (Fig. 283).

This experience demonstrates how complicated these cases can be and yet how possible it is in many of them to re-establish the bile flow in spite of many (in this case, 6) previous operations elsewhere upon the biliary tract. This patient reported that on September 15, 1949, she had one mild attack of jaundice but otherwise has remained completely well.

CASE 3. This case likewise illustrates how complicated and seemingly hopeless these cases may be. The patient had had a cholecystectomy elsewhere in 1947, at

which time, either as a result of the acute gallbladder condition for which the cholecystectomy was done or because of injury to the duct, a stricture resulted. Within the same year she was operated on again elsewhere, and an anastomosis of the hepatic duct to the duodenum was done. This failed to function, and a further operation was done elsewhere, again anastomosing the hepatic duct to the duodenum.



Fig 283. In this illustration is shown diagrammatically the type of lesion dealt with in illustrative Case 2. Note again in this case the relatively short common hepatic duct and the employment of a Y-tube of bouncing clay over which the anastomosis has been made. Note also in this diagrammatic illustration the splitting of the head of the pancreas and rotation of the duodenum to find the uninjured portion of the common duct behind the duodenum and in the head of the pancreas.

When this patient came to the clinic she was deeply jaundiced; she had had chills and fever for two months and had a large liver.

The hepatic duct was found with but a very short proximal stump remaining Its end was anastomosed over a Y-tube of bouncing clay to the common duct mobilized from the pancreas and from behind the duodenum (Fig. 279). After this anastomosis the patient became jaundiced, and a subdiaphragmatic abscess developed, which required drainage, but the jaundice failed to clear. She was sent home to die, with the idea that no more could be done. A further accumulation of the subdiaphragmatic

abscess ruptured through the bronchus, and bile was discharged through the bronchus. A communication from her physician reported that it did not seem possible that she could recover.

Recent examination of this patient indicates that the bronchial fistula has closed, bile is now draining into the intestinal tract, jaundice has cleared, and the patient appears to be at least temporarily recovering.

Last note: This patient returned to the clinic October 17, 1949, for check-up examination. Except for occasional expectoration of bile in large quantities she had been remarkably well. After examination at the clinic it was concluded that she had a biliary bronchial fistula which drained intermittently when the normal bile passages were partially obstructed and, therefore, acted as a safety valve. While she was in the hospital the expectoration of bile decreased. No jaundice was noted. Because of her relatively satisfactory condition and because we feared the effect of closing the mediastinal fistula, medical management was advised. The patient was discharged October 28, 1949.

These operations have been most complicated and trying ones. They have often exhausted our resources in surgical ingenuity in our attempts to deal with them and they have frequently disappointed us in their outcome. On the other hand, we have had to approach these cases with our minds made up that many of them are truly desperate problems demanding desperate measures, and that in many of them nearly all measures had been exhausted before the patients came to us for a last trial of surgical repair before accepting the otherwise inevitably fatal outcome which must follow. We wish, however, again for the benefit of patients who have these injured bile ducts and for the benefit of surgeons who are interested in accumulating experience in repairing them to direct attention to the tables in the latter half of this paper which present follow-up results, and to state that, considering the character of the lesion dealt with, these are far from discouraging follow-up figures.

We would like to list and illustrate in the sequential order in which we have employed them the different operative plans we have used over the years in dealing with patients who have bile duct injuries, and to comment upon and draw some general conclusions from them.

In 1930 one of us[3] became interested in bile duct strictures and published his experiences in transplanting complete external biliary fistulas into the jejunum in 14 cases in which the bile duct had been cut off before the patient came to him. In those cases, as shown in Figure 284, the external biliary fistula was preserved by coring it out of the abdominal wall in such a manner as to conserve its walls so that, with a small rubber tube inserted into the end of the fistula to prevent its collapsing, it could be implanted into the jejunum and held there by purse-string suture.

As we now know from this good-sized experience with patients who have had bile duct injuries, and many of whom had external biliary fistulas, this plan of surgical procedure was unsound in principle (only 2 have remained well). In almost all of these patients the transplanted fistulous tract closed because of two things. One was that in many of these cases spontaneous internal biliary fistulas developed as a result of rupture of the fistulous tract, most commonly into the duodenum, when that structure became adherent to the fistulous tract.

as it sooner or later does in practically all of such cases. Such adherence results in the lowering of the secretory pressure of bile within the transplanted fistulous tract and the eventual contraction and closure of the transplanted fistulous tract and later, in addition, closure of the spontaneous internal biliary fistula. It has been our experience in operating upon these 280 patients with strictures of the

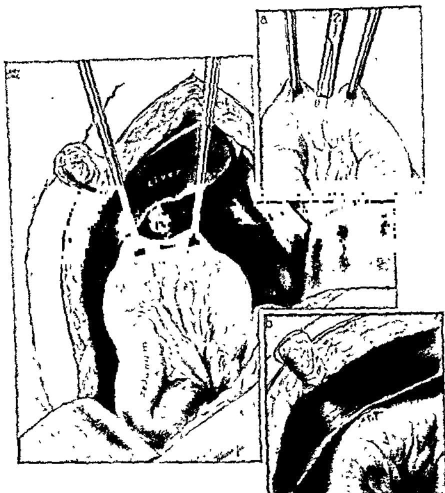


Fig. 284. In this illustration is shown the method of coring an external biliary fistula from the abdominal wall and implanting it into the jejunum Note in the main illustration the introduction of a small segment of rubber tube to prevent collapse of the fistula. In inset *a*, is shown the method of producing a small opening into the jejunum into which the fistulous tract can be implanted and in inset *b*, the fistula is inserted into the jejunum, surrounded by a silk pursestring stitch and approximated to the under edge of the liver. This method of treating strictures of the bile duct has been completely abandoned now for a good many years and the method is shown only to condemn it.

bile duct that in almost every case in which we have operated either a small internal biliary fistula was found which was inadequate in size to drain the bile into the duodenum or there were evidences of the previous existence of one which had closed by the time repair of the strictured duct was undertaken. The other factor causing this fistula transplant operation to be unsuccessful is the fact, which must have been demonstrated to everyone now many times in patients with external biliary fistulas, that the general tendency of a complete external biliary fistula is to close. This fact indicates that the contractility of

the scar tissue making up the wall of these fistulas will in practically all cases be greater than the secretory pressure of bile, the only thing which keeps these fistulas open, thus resulting in ultimate closure of the fistulous tract, whether it be external or internal.

While there may be occasional cases in which spontaneous internal biliary fistulas and those which have been implanted into the duodenum or jejunum will remain open, in most of these cases spontaneous closure of these fistulas will occur, and this operation has properly been abandoned. This is in agreement with the general principle which applies to all types of re-establishment of bile flow into the intestine, that is that it will be successful only when mucosa-to-mucosa union of bile ducts is accomplished.

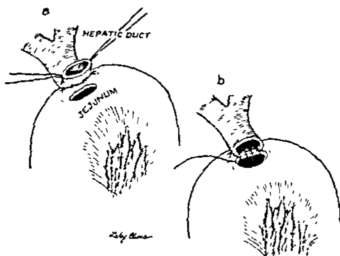


Fig. 285. Diagrammatic illustration showing the double suture line of hepaticojejunostomy when possible, and it is not always possible, to employ two suture lines, the outside one of silk and the inside one of accurate mucosa-to-mucosa anastomosis. This is the safest method *and in the hepatic duct with a large lumen there is then the best assurance of permanency of patency.*

One of the earliest operations to be employed in attempts to restore the bile to the intestinal tract in patients whose bile ducts had been severed or destroyed was the one popularized several years ago by W. J. Mayo, the mucosa-to-mucosa anastomosis of the cut end of the hepatic duct to the duodenum or jejunum, choledochoduodenostomy or choledochojejunostomy, or hepaticoenterostomy.

When accurate mucosa-to-mucosa suture is made of the cut end of a severed and dilated hepatic duct to the duodenum or jejunum, reinforced by outside sutures to insure the security of the anastomosis (Fig. 285), the communication between the duct and the intestine when it is adequately large will remain permanently patent in most of the cases. This is a very useful and effective surgical procedure. Its drawback is that with no sphincter between the liver and the intestinal tract there will be in many of the cases regurgitation of intestinal contents of the duodenum or jejunum up into the biliary tree, with frequent chills, jaundice, and fever as the result of the cholangitis brought about by this regurgitation.

Although numerous suggestions, such as lateral anastomoses between the two limbs of the loop of jejunum into which the fistula has been transplanted,

enfolding of the loops or the use of single segregated loops, have been employed to improve this procedure, it can be said with certainty that to maintain protection of the liver from ascending infections after duct repairs there is, when the operation is possible, no substitute for preservation of the sphincter of Oddi.

This operation of biliary intestinal anastomosis is one which will not infrequently have to be employed when the caliber of the common duct which has been mobilized from the head of the pancreas is so small, atrophied, and fibrosed from disuse that it will not be possible to dilate the end used for the anastomosis to the distal end of the hepatic duct. Attempts to dilate fibrosed and atrophic

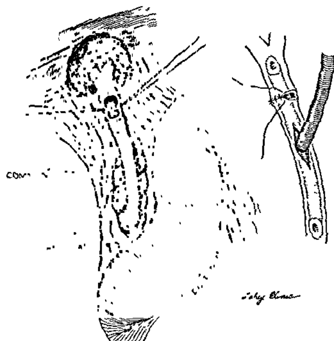


Fig. 286. In this diagrammatic illustration is shown the plan proposed by Cattell and Lahey of mobilizing the duodenum to the left, of recovering the uninjured portion of the common duct from the head of the pancreas by splitting it, the direct end-to-end anastomosis of the recovered common duct to the hepatic duct, and the introduction of a T-tube with one limb passing through the line of anastomosis to maintain its patency.

common ducts recovered from the head of the pancreas have resulted in most of the cases in splitting the common duct and spoiling it. In other cases, due to the scarring and fibrosis as the result of previous attempts at repair, it will not be possible to find the lower end of the common duct and employ the plan which we have described in this article, mobilization of the common duct from the head of the pancreas and direct end-to-end anastomosis of the ducts. It has been our experience that the number of cases in which the lower end of the cut duct cannot be found in the head of the pancreas will progressively diminish as one's experience with finding it increases.

It is, therefore, of interest and encouragement to call attention to Table 10 in the follow-up portion of this paper in which satisfactory results were obtained in 73.1 per cent of the patients treated by this method.

When restoration of the bile ducts can be so accomplished as it often can by freeing the lower end of the common duct from the pancreas and by mobili-

zation of the duodenum and end-to-end anastomosis of the ducts, as will be later discussed, so that bile flows without obstruction along the main bile ducts into the duodenum and when the bile passages are protected against ascending infection by the preservation of the normal sphincter of Oddi, the most ideal surgical repair of an injured bile duct has been accomplished (Figs. 283, 286 and 287).

The next step in the sequence of our attempts to repair injuries to the bile ducts was that of employing, as a substitute for the duct defect, tubes of various types of material, rubber, vitallium and last in sequence of appearance, a material

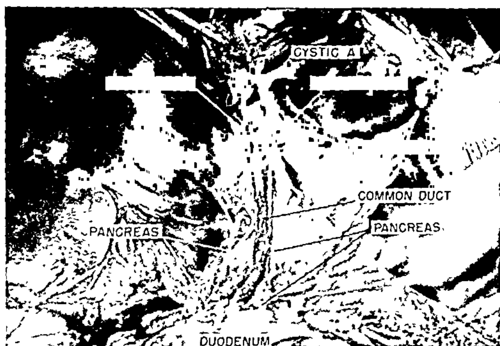


Fig. 287. Photograph of a dissection made on an autopsy specimen, showing the intra pancreatic dissection of the lower end of the common duct. While it does not show relationships well it serves to authenticate the diagrammatic drawing in Figure 286.

called bouncing clay (silicon) to bridge defects in the injured ducts. These attempts to bridge defects by tube implantation were made before we developed the plan of mobilizing common ducts from the head of the pancreas and direct end-to-end anastomosis of the ducts. This silicon material, like rubber, is capable of bouncing and stretching, and is so flexible that it will readily adjust itself to the tortuous angulations of the fistulous tracts into which these tubes must be implanted when they are used, as they often are, as makeshift procedures when other more ideal plans are not feasible.

In our attempts to bridge defects in injured ducts we have employed implantations into the bile ducts of tubes of one of these types of material ten times from 1940 to 1948, with only 20 per cent satisfactory outcome (Table 11). While these tubes have successfully bridged the defects made by loss of varying sections of the duct and have remained patent varying lengths of time, the general tendency of such implanted tubes has been to become plugged in from one to two years by the crystalline elements of the bile passing through them and likewise the general tendency has been for the defect segments to

stricture again when the tube has passed as it has in many of the cases in spite of all measures to retain it in place.

Some of our experiences with the implantations of these tubes will be of interest and may be of value to others who have to deal, or may have to deal, with strictures of the bile ducts of such complicated character that it may not be possible to employ the ideal plan we wish to describe.

Case 1, reported earlier in this paper, is of interest in connection with these types of duct injuries in that 7 operations were done upon this patient's bile ducts. Three tubes were implanted in the ducts, each of which plugged and required removal. The last tube was removed without introducing another tube and the patient has now gone almost five years without biliary obstruction. It is to be realized, however, that in both of these cases the sphincter of Oddi remained intact to protect the liver from the effects of ascending infections of the biliary tract.

We have implanted vitallium tubes 46 times in patients with strictures of the bile ducts. So much which is unintentionally misleading has been written and said about the use of vitallium tubes in strictures of the bile ducts that we wish to discuss the employment of these tubes following our experience with them. In discussions of papers on this subject at surgical societies, Lahey has stated that we believe the original plan of the employment of tubes made of vitallium was wrong in its conception. Vitallium tubes were suggested as a means of bridging gaps of duct defects following duct injuries largely because vitallium, first proposed by Charles Venable, is a nonelectrolytic metal and is so well tolerated by the tissues elsewhere, as with screws, bone plates, hip cups, skull defects and so forth. This tissue tolerance feature of vitallium tubes is of little significance in the repair of strictures of the bile ducts since there has never been any problem of tissue tolerance in the implanting of any of the tubes, rubber, vitallium or bouncing clay. All three materials have been equally well tolerated by the tissues. The real problem which concerns us in the use of tubes of any material is, is there less likelihood of plugging in one tube as compared with the other? There appears, from our experience, to be little difference in tubes of any of these three materials in their tendency to plug with inspissated bile.

There are no advantages in the use of implanted vitallium tubes over rubber or bouncing clay tubes and there is at times a real disadvantage in their use in that they are rigid and inflexible. Because of this, in certain cases they are very difficult to introduce since they do not adjust themselves to the angulations sometimes found in the bile tracts encountered during attempts to repair strictures or duct defects where previously unsuccessful reparative operations have preceded the repair being made.

It has been our experience also that these tubes, in spite of the tab attached to them, as shown in Figure 288, can and have been passed, tab and all, into the duodenum through the sphincter of Oddi even when they have been anchored by a silk stitch through the hole in the tab attached to the tube. One would hardly imagine that such a metal tube as shown in Figure 288, with such a metal tab attached at right angles to the tube and sutured in by a silk stitch could pass through the [illegible]

[illegible] them. In addition,

serious complications have been reported by others as the result of the passage of these tubes into the duodenum. To demonstrate this inclination of tubes placed within the ducts to pass into the duodenum, we would like to call attention to Case 2 in the 3 cases reported in this paper in which a successful repair was done. In this case one of the six previous attempts at repair before coming to us consisted of the introduction of a T-tube into the strictured duct with one end of the T-tube passing through the stricture, only to have the entire T-tube, including its external limb, spontaneously pull into the common duct and the entire T-tube to be passed into the duodenum, and be discharged in the feces.

While we have never employed these vitallium tubes as a method of connecting a cut hepatic duct directly to the duodenum when the lower end of the common duct has not been found, this has been reported by others a sufficient number of times, with hemorrhage, perforation and death as the result of pressure from the tube within the duodenum to make this, we believe, an unwise procedure.

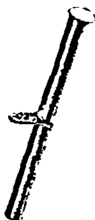


Fig. 288. The type of vitallium tube commonly employed in duct strictures. Note the projecting tab in spite of which, as stated in the text, these tubes have been passed through the common duct, through the sphincter of Oddi and into the duodenum

Bouncing clay (silicon) tubes have the advantage over tubes of other material only in that they can be readily cast into any shape, size, with lumens of any caliber and with collars cast on the tubes to facilitate their retention and discourage them from being passed. Spontaneous and premature passing of implanted tubes through the sphincter of Oddi into the duodenum is one of the real problems which we have encountered in the implantation of tubes of any type and material except those of the Y type. It is this tendency of implanted tubes to pass that has inclined us more and more in our later cases toward the use of T-tubes which can be irrigated and tend less to be passed.

DESCRIPTION OF A NEW PRINCIPLE IN THE REPAIR OF STRICTURES OR LOSS OF SUBSTANCE IN THE BILE DUCTS

From time to time in discussions before medical societies of papers on bile duct strictures, Cattell[1, 2] and one of us[7] have mentioned a plan which they have de-

hesitate to make the search for it or are intimidated by the distressing bleeding from the opened head of the pancreas and give up the search to turn to a simpler but less physiologic procedure, hepaticoenterostomy or the Longmire procedure of severing the left lobe of the liver, finding the left hepatic duct and implanting it into the jejunum.

It was not until we had learned how to find common ducts in the head of the pancreas and behind the duodenum—largely from our experiences in dissecting and demonstrating common ducts from the head of the pancreas in indurated duodenal ulcers adherent to them in order to remove the ulcer—that we discovered that the common duct could in most cases be so freed that it could frequently be brought up to the cut end of the hepatic duct sometimes even within the substance of the liver, for direct end-to-end repair by suture.

In the course of an experience with these 280 strictures of the common and hepatic ducts, we have learned to turn the duodenum over, to split the head of the pancreas as it projects to the right of the lateral wall of the duodenum, to find the common duct within the pancreas, and so to mobilize it out of the head of the pancreas and from the back of the duodenum that a surprising amount of intact common duct may be found, in many cases of such length and mobility as to make it possible to attach it to the remaining end of the hepatic duct so long as any of the common hepatic duct remains as a single tube (Fig. 283) or even a double tube.

The first step of any operation in which demonstration of the common and hepatic ducts after previous operations on the biliary tract is involved concerns itself with obtaining exposure of the region of the duct defect or injury without damaging the structures which must be dealt with before the common or hepatic duct can be found and dealt with, particularly the duodenum, hepatic flexure, portal vein, and hepatic artery.

The first step in obtaining an exposure of the region of the common and hepatic ducts in any patient who has had a previous operation on the biliary tract consists in finding the attachment of the hepatic flexure to the under surface of the liver at its outer edge. With gentle pressure to the left on a retractor placed upon a wet pad over the hepatic flexure, the line of adhesions of the hepatic flexure to the under surface of the liver can be demonstrated and gently separated from the liver edge and from below upward and inward by scissors or by means of a wiping swab (Fig. 276). This gentle wiping of the hepatic flexure away from the under surface of the liver along which is an established line of cleavage is continued until the point at which the duodenum is adherent to the under surface of the liver at its hilum is demonstrated. At this point the pyloric portion of the stomach is sought above (Fig. 283), where it is often adherent to the liver at the point at which the left lobe of the liver joins the right. This is gradually separated from the liver, by dissection from above downward until the duodenum is gradually, safely and entirely freed from its attachment to the hilum of the liver and so wiped away and to the left that the entire region of the common duct, hepatic artery, and the foramen of Winslow are made plainly visible. It is at the point of attachment of the duodenum to the hilum of the liver that small spontaneous internal biliary fistulas are quite consistently encountered and must be dealt with by closure of the fistula into the duodenum by inversion suture.

We have over the years developed and employed this method of exposing common ducts at secondary operations on the bile tracts because we have had to do so many of these secondary operations upon the bile duct. It has proved useful and safe, even in patients who have had as many as six previous attempts at duct repair. It makes it possible to obtain safe re-exposure of the bile ducts in a relatively short period of time (Fig. 276). Once the duodenum and hepatic flexure have been detached from the liver and held to the left, the same maneuver of exposure as shown in Figure 276 by retraction on the liver to the right, the hepatic flexure and duodenum to the left, will expose the foramen of Winslow, will expose the common and hepatic ducts if they are intact and will expose the position where the ends of the ducts are to be sought.

At this stage of the procedure the first step should be the attempt to find and demonstrate the cut end of the hepatic duct in or near the hilum of the liver since the lower end of the duct, even if freed and mobilized from its position behind the duodenum and pancreas, is of no value unless the upper end of the duct, hepatic, can be found and demonstrated so that an anastomosis can be made to it. It is for this reason that the first effort should be to find and demonstrate an adequate amount of the stump of the hepatic duct.

At times the cut end of the hepatic duct may be found by following up to the hilum of the liver the fistulous tract, which at times extends to the external abdominal wall and at other times extends from its entrance into the duodenum up to the hilum of the liver. In many other cases the cut end of the duct will have closed completely and if there remains a sufficient portion, it can sometimes be identified by its clubbed end, not unlike the club-like end of a bass drumstick. At other times as a result of repeated unsuccessful attempts to repair the duct, the hepatic duct will be represented only by a mass of firm scar tissue in the hilum of the liver, with no identifying signs of what is and what is not hepatic duct. In such cases one is aided in discovering the duct by following the course of the hepatic artery as it is palpated or visualized up to the point where it disappears in the liver or by demonstrating the portal vein and following it up to the point where it disappears into the liver and searching just above it and to the right where the hepatic duct or ducts become intrahepatic. In other cases, the duct will be discovered only by needling the liver at its hilum and the demonstration of the bile escaping from the needle or needle hole after the needle is withdrawn. In some cases, taking care to avoid the portal vein, it will be necessary to use a fulgurating loop to dissect away tissue at the hilum of the liver until the intrahepatic portion or portions of the duct or ducts can be demonstrated as a stump or stumps of the ducts.

The principle involved in the plan which Cattell and Lahey have developed is concerned, as already stated, with the demonstration of the retroduodenal and intrapancreatic lower portions of the common bile duct. This is the essential feature of the plan which makes demonstration and mobilization of the duct so possible that direct anastomosis of the demonstrated and mobilized common duct to the end of the hepatic duct can be employed. The first step in finding the common duct is the freeing of the second portion of the duodenum and so rolling it to the left, as shown in Figure 286, that the portion of the pancreas behind the outer part of the duodenum is exposed. With the duodenum so rolled to the

left, the lower edge of the head of the pancreas can be split a little at a time until the intrapancreatic section of the uninjured portion of the common bile duct becomes visible and can be so dissected out of its position behind the duodenum and in the head of the pancreas that all that remains of it is completely demonstrated up to the point where it enters the wall of the duodenum (Fig. 287).

Dissection of the lower end of the common duct out of the head of the pancreas is tedious and troublesome. It is made so particularly by the large number of small vessels which bleed as the pancreas is divided longitudinally in the direction in which the duct runs, as shown in Figures 283 and 286. With mosquito hemostats and silk ties and with patience, these troublesome vessels can ultimately all be safely controlled, although at times their complete control seems discouragingly impossible. We have many times been aided in the discovery of

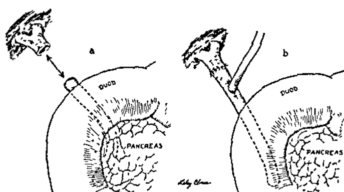


Fig. 289. Note in *a*, the curving course of the common duct through the head of the pancreas to the back of the duodenum, and in *b*, the amount of duct which can be gained as this duct is freed from the head of the pancreas so that it can be approximated to the cut end of the common hepatic duct.

the intrapancreatic common duct by remembering its relationship as it runs in a roughly parallel course to the hepatic artery which can often be palpated within the scarred tissue caused by previous operative procedures, at other times by recognizing the entry of the duct into the duodenum as this structure is freed from the pancreas and rolled to the left and at other times by the demonstration of the course of the portal vein. It will never be necessary and is positively unsafe to detach the duodenum completely from the pancreas throughout its entire circumference lest its blood supply be so endangered as to result in necrosis of the duodenum.

When the common duct is found within the pancreas (Figs. 283 and 286) it can gradually be dissected out of it, a small slit can be made in its wall to demonstrate that a probe or a small catheter can be made to pass into the duodenum, the probe can then be passed upward to demonstrate the upper limits of the duct and the duct completely dissected out of the scar tissue up to its uppermost end. This is extremely important as the upper end of the duct will frequently be found to be deeply buried in the scar tissue of previous attempts at repair and it is important to obtain and preserve the greatest possible length of this duct.

It is to be recalled that the course of the duct through the head of the pancreas and behind the duodenum is an angulated one, and that when the duct is freed from this intrapancreatic position and carried directly upward to be approxi-

mated (Fig. 289) to the lower end of the hepatic duct, its course is much more direct than before it is mobilized and often makes it possible to gain, 1, 2 or more inches toward the approximation of the ducts. It is also to be remembered that as the duodenum is mobilized from the head of the pancreas and rolled inward there will be another gain in the amount of duct available to approximate to the lower end of hepatic duct.

Once the common duct has been mobilized and the mobilization can be carried down to the point where the duct enters the duodenum, it is then necessary only to make the accurate end-to-end anastomosis with the hepatic duct after ascertain-

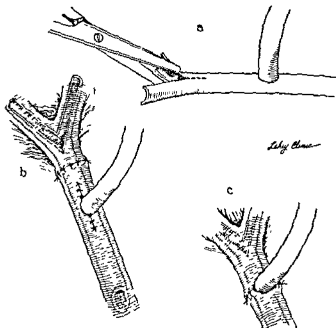


Fig. 290. This illustration serves two purposes, one, to show the method of splitting one limb of a T-tube (*a*), so that each end of the split tube can pass respectively into the right and left hepatic ducts when anastomosis must be made to a short stump of hepatic duct. It is in this type of injury also that the type of tube devised by Lahey may also be used, and is shown in Figure 280. The other purpose of this illustration is to show the wrong way of introducing the tube so that it emerges through the suture line, as shown in *c*, and the proper way of introducing the tube by the plan devised by Lahey in *b*, in which the tube emerges from a separate suture line and the line of anastomosis remains completely intact.

ing that the ends of the ducts can be brought together without tension and that the lower end is of adequate caliber to match the upper end. This anastomosis is done by means of interrupted fine silk sutures, the back row being placed first, then a posterior row of interrupted catgut sutures to approximate mucosa to mucosa. A T-tube is then introduced into a slit in the common duct below the end of the common duct so that the upper limb passes into the hepatic duct; the anterior line of interrupted catgut and silk sutures is placed about the tube to insure the absence of any narrowing of the reconstructed duct. This plan was described in an article on duct strictures published in 1949,[7] as shown in Figures 281 and 286.

A suggestion made by C. E. Sedgwick, now a member of the permanent surgical staff of the clinic, while serving as an assistant to Lahey at the time of some of these trying operations, has proved of such great value that we have since em-

ployed it in all anastomoses of the ducts of this type. It consists of so wrapping the entire anastomosed section of duct in gelfoam strips that the suture line is temporarily reinforced. This has the advantage of aiding in making the suture line watertight until healing has taken place (Fig. 281, *b*).

As shown in Figure 290, *c*, when we first began to repair crush strictures of the hepatic duct and to do plastic repair of the ducts, we introduced the two limbs of the T-tube into the open ends of the ducts and reconstructed the anastomoses about the tube. Later we realized that when the tube was removed, even several months or a year later, there remained a defect in the duct wall which healed only by cicatrization. Because of this Lahey employed the plan of introducing the T-tube, as shown in Figure 290, below the anastomotic line, permitting the upper limb of the tube to pass upward through the line of anastomosis to maintain its patency (described in *Annals of Surgery* in 1937[4]). This plan has been applied to the use of T-tubes to support end-to-end anastomosis of the ducts and results in a complete circular and accurate anastomosis which remains intact when the T-tube is withdrawn at a later date since the tube emerges from its slit in the duct at a point lower than that at which the anastomosis is made.

We have left the T-tubes in place up to periods as long as fourteen months after operation. We believe they should be left in place over a long period of time until the mucosa has grown well over the line of anastomosis and until the greatest possible degree of molding has taken place as a result of the presence of the T-tube. We have instructed patients to irrigate the tubes gently night and morning with small amounts of sterile water or salt solution to aid in maintaining their patency.

Little need be said about the short crush type of stricture since we have already described a satisfactory plan for its management, as illustrated in Figure 277, *c* to *f* (100 per cent satisfactory results in the follow-up, Table 8). Should this crush type of stricture involve any considerable part of the duct so that there is difficulty in obtaining enough lax duct to accomplish the plastic repair or should excision of the stricture seem the most satisfactory plan of obtaining good patency of the re-established duct, the lower end of the common duct can be mobilized as described, and a sufficient amount of duct obtained to accomplish direct end-to-end anastomosis.

It would be wrong in describing this operation to leave the impression that all one has to do is to find the end of the hepatic duct, to mobilize the common duct from its position behind the duodenum in the pancreas, to do an end-to-end
anastomosis, and to put in a T-tube and a ... ry outcome automatically
would result. Unfortunately, anyone who ha ... a number of these cases
of stricture of the ... s knows that he ... to many depressing dis-
appointments, o ... t frequent caus ... will be the presence of
infection, mucus, ... even stones ... trahepatic ducts above
the injury to the ... t of the infe ... stasis a ... *with*
these strictures. In ... se, a very s ... tomo ... om-
plished. A T-tube ... over a co ... o ... be-
cause of the fact tha ... operatio ... of
s and small gallst ... and re ... ct,
ately upon rem ... dic ... l.

These complications were demonstrated to be the result of the infection and stones which continued to form within intrahepatic bile passages.

There have been 11 cases in which the patient, the nurse, or the surgeon has inadvertently pulled the T-tube out of its place after operation, thus resulting in narrowing and in the need for reoperation and reintroduction of the T-tube. For this reason, we wish strongly to urge that dependable measures be taken to insure the fixation of the tube to the abdominal wall in such a way that it will not be

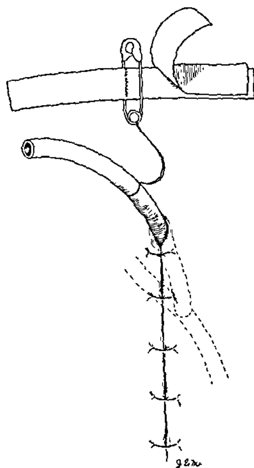


Fig 291. In this illustration is shown the method devised to attempt to keep the T-tube from being pulled out. A black silk stitch is tied accurately with sufficient pressure to hold but not sufficient pressure to occlude the tube. It is then tied to a safety pin which is maintained on the abdominal wall by two strips of adhesive plaster, one passing through the safety pin and one over it.

accidentally removed (see method described in latter part of paper, Figs. 291 and 292). In one of the cases the tube, due to the sticky bile, became adherent to the patient's undershirt and on taking off his undershirt, the T-tube was pulled out, so that reoperation was necessary. In another the tube became adherent to the abdominal binder and as the nurse lifted the abdominal binder off, the tube was withdrawn. These accidents can occur in any case and should be guarded against because of the fact that too early withdrawal of the tube will permit stricturing again at the point of anastomosis.

Another precaution which must be taken in these cases is that of careful removal of the drain. Since in many of these cases there will be considerable oozing

from the under surface of the liver as a result of the separation of the hepatic flexure and the duodenum from the liver and as a result of the severance of the numerous adhesions in the region of the operation, and also since frequently there is oozing from the small vessels in the edge of the pancreas as it is separated in finding the common duct, it will always be necessary to introduce a drain. On one occasion in the removal of the cigarette drain the T-tube was acci-

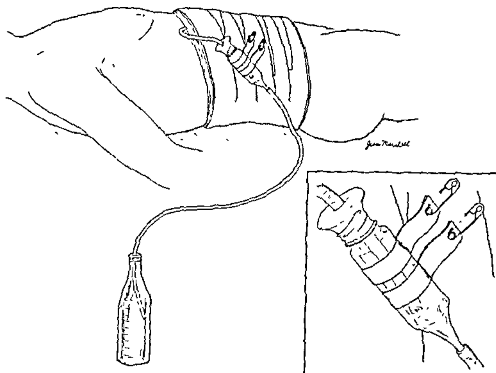


Fig. 292. In this illustration is shown diagrammatically the method of introducing the limb of the T-tube into an asepto syringe, the mouth of which has been covered by a rubber dam [illegible] bottle. By this plan there is a break in [illegible] the bedclothes, requiring frequent changing.

dentally pulled out with the drain. It is much better we now believe to employ gelfoam to control oozing and to make use solely of a Penrose drain without gauze for drainage rather than to employ a cigarette drain; the drain can then be withdrawn without danger to the indwelling T-tube.

FOLLOW-UP DATA ON 229 REPAIRED BILE DUCTS

In an effort to evaluate the results obtained in applying the principles outlined in this paper and developed in this good-sized experience in reconstructive surgery of the biliary tract, and in an effort to learn whether these principles are sound, an intensive follow-up study has been made. Of the 280 patients operated upon for various types of bile duct strictures, 41 were treated in the years 1948 or 1949 and have been excluded from this study as too recent to be of value in determining end results, so that 239 patients are left for study. (We do not believe that a report on a method of bile duct repair is of value until the repair has existed for a period of two years.) As noted earlier in the text, 10 patients

were lost to the follow-up study, so this leaves a group of 229 patients available for follow-up study. The study has been divided into two periods: the first extending from 1917 to 1939 and the second from 1940 to 1948. In the first period 54 patients were available for study, with 6 lost to the follow-up study, and in the second period 185 cases were studied with only 4 being lost to the follow-up study. Thus, for the entire series we are certain of the follow-up on 96 per cent of the cases and for the period from 1940 to 1948 we have succeeded in following 98 per cent of the cases by clinic visit, letter, or both.

The average age of this group of 239 patients was 43.8 years, of which 185 were women and 54 were men, or a ratio of females to males of 3 to 1.

It can be plainly seen in Table 1 that the majority of bile duct strictures, 208 in number, were secondary to biliary tract surgery; only 3 were secondary to

Table 1. Etiology of Strictures

		CASES
Surgical trauma:		
1. Biliary tract surgery	198	
2. Gastrectomy	3	
3. Inflammatory	7	208
External trauma		2
Primary inflammatory		2
Adhesions		1
Foreign body		1
Congenital		1
Fibrosis of ampulla		24
Total		239

partial gastrectomy. Eighty-one per cent of this series were due to operative trauma.

An investigation into the histories before the patients came to us was made to determine what the indications for the original operation on the gallbladder were and in 125 histories this information was available. There were 25 cases of acute cholecystitis (gangrene, perforation, and empyema included), and 100 cases of chronic cholecystitis or cholelithiasis, or both. Thus, 80 per cent of these 125 cases available for study had had what may be considered an elective operation, and 20 per cent were for an acute gallbladder condition. In this entire series of traumatic bile duct strictures, in only 4 to 5 per cent of the cases was it recognized at the original operation that injury to the bile ducts had occurred. These figures indicate that in the majority of cases gallbladder surgery is elective surgery and therefore can be performed as a deliberate and planned procedure. They suggest also that at the time of operation the anatomy was not carefully and plainly demonstrated because of the fact that such a small number of duct injuries was recognized at the original procedure.

In addition to the factors (described in the earlier part of the paper) which directly contributed to these duct injuries, that is hemorrhage from the cystic or hepatic artery, failure to demonstrate the cystic-common duct junction, and anomalies of the duct system, obesity with its added technical difficulties was

present in 25 per cent of this group of cases of stricture of the bile ducts. Other factors such as the performance of choledochostomy in the presence of a very small common duct, trauma to the posterior wall of the common duct during choledochostomy, impacted stones at the cystic-common duct junction, gastrectomy and duodenectomy for low-lying duodenal ulcers and pancreatitis and acute cholecystitis with their associated edema of the gastrohepatic omentum obscuring the anatomy, were present in the operative reports in a few of the cases studied in this series.

Table 2 is of interest because it demonstrates what a patient with a bile duct stricture faces physically, financially, and mentally. It shows, for example, that from 1940 to 1948, 185 patients with bile duct strictures were treated at this clinic. Much as we dislike to insert this sentence it would be unfair to the surgeons operating in this clinic not to say that only one of these duct injuries occurred in this clinic and that it was immediately recognized and promptly and successfully repaired. This group of patients had had 359 operative procedures done before coming to the clinic and 273 operations were performed after coming to the clinic, or a total of 632 surgical procedures. The entire series of 239 cases of bile

Table 2. Total Operations Performed Including the Original Operation

	NUMBER OF PATIENTS	OPERATION ELSEWHERE	LAHEY CLINIC	TOTAL
1919 to 1939	54	58	71	129
1940 to 1948	185	359	273	632
Total	239	417	344	761

duct strictures had a total of 761 operative procedures. Table 2 indicates the serious responsibility accepted by a surgeon who undertakes this type of bile duct repair and what the patient must go through if the initial attempt at repair is unsuccessful. This total of 344 operations at the clinic on the injured bile ducts performed on 239 patients represents secondary operations in densely adherent, distorted, and complicated anatomy. Many of these patients were deeply jaundiced at the time of operation and had in many cases limited liver function. Several of these patients had had 3 or more (in one, 7, and in another, 8) previous operations on the biliary tract. In this entire group of cases there were 24 postoperative deaths in the total of 344 operative procedures, or a procedure mortality of 7 per cent. In the period from 1940 to 1948 there were 273 operative procedures on 185 patients with 12 deaths, or a procedure mortality of 4.4 per cent. Since each one of these operations is such a long and difficult one, and each succeeding one more difficult, it is unfair to report mortality in these cases except as procedure mortality.

In this follow-up the results were graded as follows· excellent—asymptomatic; good—with mild symptoms, for example, pain, occasional chill without clinical jaundice, mild attacks of cholangitis at widely spaced intervals; unsatisfactory—recurrence of serious symptoms indicating obstruction, that is, severe chills, fever and obvious jaundice requiring reoperation or resulting in eventual death.

In Table 3 the locations of the strictures have been listed in every case and the results given for the entire group regardless of the type of repair. It may be

seen from this table that strictures have occurred at all levels in the extrahepatic biliary tree. The majority of strictures, however, were either of the common hepatic duct, the common duct, or extensive defects in which the entire extrahepatic and extrapancreatic section of the biliary tree had been excised or destroyed by repeated previously attempted reconstructive surgery. In the final end results it may be seen that 79 per cent of the cases followed had either an excellent or satisfactory result by all the various methods of reconstruction. There were 24 postoperative deaths, or 10 per cent for the entire series. The 10 cases which were lost to the follow-up and the 24 postoperative deaths were omitted in calculating these general results.

Table 3. Location and General Results—1917 to 1948

LOCATION OF STRICTURE	TOTAL	RESULTS Good to excellent	RESULTS Unsatisfactory	POST-OPERATIVE DEATHS	NO FOLLOW UP
Right hepatic duct	7	3	2	1	1
Left hepatic duct	1	0	0	0	1
Common hepatic duct at bifurcation	28	19	3	6	0
Common hepatic duct	41	28	7	6	0
Cystic-common duct junction	18	16	0	1	1
Common duct	45	27	10	2	6
Common hepatic and common duct	25	20	3	1	1
Extensive—common and hepatic ducts	46	26	14	6	0
Multiple strictures	4	2	2	0	0
Fibrosis of ampulla	24	20	3	1	0
Totals	239	161	44	24	10
Per cent		78.5		10	

The two periods into which the cases have been divided are quite different in many ways, particularly as to the methods of repair employed. From 1917 to 1939 few of the principles now employed were used. In this early period a number of external biliary fistulas were transplanted and attempts were made to bridge duct defects with rubber tubing. During these early years of our experiences with these patients we were without the benefit of vitamin K and without as good an understanding of the importance of preparing a badly damaged liver for surgery as we now have. Finally, during these years we did not have the potent antibiotics of today. These factors account for an operative mortality of 22 per cent during the years 1917 to 1939. The three main causes of postoperative deaths in the early group were hemorrhage, liver failure, and peritonitis.

Table 4 represents the results by all operative methods for this period from 1917 to 1939. A total of 36 patients in this group was available for study; the postoperative deaths and the 6 patients lost to follow-up were excluded. Twenty-seven patients were considered to have excellent or good results and 9 had grossly unsatisfactory results. In every instance in which the result was unsatisfactory, the patient died, and the average length of life was 25.5 months after attempted repair. When those patients who were thought to have good results, that is, with mild symptoms, were followed over long periods of time, 4 out of the 10 had died, the average length of life after repair being 9.6 years. The pattern of events

in these patients who died was the same. The attacks of biliary tract obstruction became closer and closer together until jaundice was constant. The liver which gradually enlarged began finally to decrease in size as the spleen enlarged greatly. These patients were repeatedly hospitalized for hemorrhage, usually from the gastrointestinal tract, and death ensued from a massive gastrointestinal hemorrhage or from liver failure. Thus, of the patients who were thought after a brief follow-up to have good (not excellent) results in this group of cases, 40 per cent had died when these patients were followed for ten years or longer. It can be appreciated, therefore, since the average age of these patients in whom a stricture occurred was 43.8 years and in whom a satisfactory repair was not accomplished, that these patients with but few exceptions will die at an age far short of their life expectancy. The final salvage in this group of patients treated from 1917 to

Table 4. Results by All Methods from 1917 to 1939

	NUMBER		PER CENT
Total cases	54		
Postoperative deaths	12		22
No follow-up	6		
Cases for study	36		
Excellent results		17 }	75
Good results		10 }	
Unsatisfactory results		9	
Final results			
Cases for study	36		
Excellent and good results		23*	
Unsatisfactory results		13	

* 64% of cases for study (36) or 42.6% of total (54) cases

1939 (Table 4) was 23 out of 54 or 42.6 per cent of the entire group of patients, a figure by no means to be critical of in the light of the period and the seriousness of their condition.

During the period from 1940 to 1948 the following principles of bile duct reconstruction now in use in the clinic were developed and applied: (1) direct duct end-to-end anastomosis with a T-tube implanted through a separate opening in the bile duct (Fig 286); (2) dissection of the intrapancreatic portion of the common duct, mobilization of the duodenum and end-to-end anastomosis of the ducts (Figs. 283 and 286); (3) application of the Mikulicz principle by suturing the right and left hepatic ducts together and incising the sutured common wall between the two ducts thus creating a single lumen which could be anastomosed to the distal segment of the duct* (Fig. 278); (4) employment of vitallium and bouncing clay in reconstructive surgery of the bile ducts and direct anastomosis of the hepatic duct to the jejunum (Fig. 285). These 185 cases were analyzed as a group and each method was separately analyzed. A follow-up was accomplished in all but 4 cases, or in 98 per cent of this group.

Table 5 illustrates the results by all methods of bile duct reconstruction employed in 185 cases from 1940 to 1948. There were 12 postoperative deaths, or an operative mortality of 6.5 per cent. There were 273 operative procedures on 185

* Suggested and employed by Cattell in this clinic.

patients with a procedure mortality of 4.4 per cent. Of the 169 patients who could be followed, 138 had an excellent or good result, or 81 per cent had a satisfactory result by all methods of repair for all types of strictures. In the unsatisfactory group, there were 31 cases, of which 17 patients are dead (55 per cent) and 14 (45 per cent) are still alive with serious symptoms and have but a short prospect of life. As evidence of our increasing ability to handle these cases with safety, during the years 1947 and 1948, 71 patients were operated upon for stricture of the bile duct, with 1 postoperative death, or an operative mortality during those two years of 1.4 per cent.

In the following paragraphs and tables we have evaluated each separate type of procedure in the 1940 to 1948 series in order to satisfy ourselves whether or not the methods we are advocating and employing are sound in principle and results. The types of reconstruction which were evaluated were: (1) direct end-to-end anastomosis when enough duct was available (Fig. 286); (2) dissection of

Table 5. Results by All Methods from 1940 to 1948

	NUMBER		PER CENT
Total cases	185		
Postoperative deaths*	12		
No follow-up	4		
Cases for study	169		
Excellent results		50	81.7
Good results		88	
Unsatisfactory results		31	18.3†

* Procedure mortality, 4.4%, patient mortality, 6.5%.
† 55% are dead, 45% living with serious symptoms.
From 1947 to 1948 there were 71 patients operated on with 1 postoperative death (1.4%).

the distal common duct which lies within the pancreas and which usually remains uninjured, and mobilization of the duodenum when enough duct was not available without this (Figs. 283 and 286), (3) a plastic type of procedure employing the Heineke-Mikulicz principle (Fig. 277, *c*, *d*, and *e*); (4) dilatation and T-tube insertion; (5) biliary-intestinal anastomosis (Fig. 285); (6) transplantation of external biliary fistulas (Fig. 284); and (7) bridging of defects of the bile duct by tube implantation (Fig. 282).

In the past decade we have in this clinic repeatedly advocated the re-establishment of bile duct continuity by direct end-to-end, mucosa-to-mucosa anastomosis. When this procedure is feasible it preserves the important sphincter mechanism of the ampulla of Vater, and gives the most satisfactory and lasting results, even though it is occasionally necessary later to reoperate upon some of these patients and perform a plastic type of procedure upon the sutured ducts or dilatation of the narrowed anastomotic line with tube implantation, or both. Table 6 illustrates the results in 78 patients who had as their initial operation an end-to-end anastomosis. Three postoperative deaths occurred and 2 patients were lost to follow-up so that 73 cases were left for study. Of this number, 44, or 60.2 per cent, had a satisfactory result without requiring further procedures. Thirteen required a secondary operation on the bile duct, either of a plastic nature or a dilatation of the anastomotic line with tube implantation, or for the removal of a plugged per-

manent type of tube (vitallium, bouncing clay, or rubber), before a satisfactory result was obtained. A total of 57, or 78 per cent, of these patients, had a good result by this plan of treatment. Six patients finally required a biliary-intestinal (jejunum) anastomosis before a satisfactory result was obtained. Of 73 patients, 63, or 86.2 per cent, had a good result when the initial procedure was an end-to-end anastomosis.

Table 6. End-to-End Anastomosis, from 1940 to 1948

	NUMBER		PER CENT
Total cases	78		
Postoperative deaths	3		3.9
No follow-up	2		
Cases for study			
Excellent results		16	78*
Good results		28	
Secondary operation on bile duct		13	
Unsatisfactory results		16†	
Total cases for study		73	

* Of those studied 44, or 60 2%, obtained good results after one operation.
† 6 of 16 patients had biliary intestinal anastomosis, with good results.

The technical details for demonstrating the intrapancreatic portion of the common duct for the purpose of anastomosis to the proximal section of the duct (hepatic) have been described in detail earlier in this paper. Up to 1948 this procedure had been performed 27 times (Table 7), and it has been employed at least that many more times since that date. The latter cases, however, are not included in this study because they are too recent for follow-up study. Attention is called to the fact that in 21 of 27 patients the bile duct stricture was graded as extensive and in 21 of 27 cases two or more procedures (7 in one case and 8 previous operations in another) had been performed elsewhere before the patients came into our hands for further attempts at repair. Two methods were employed. In 21 cases a direct end-to-end anastomosis of the ducts was performed and in this group 80 per cent had a good result. In 6 cases after the distal bile duct had been mobilized from within the substance of the pancreas, a defect remained due to insufficient amounts of duct available between the proximal and distal ends of

Table 7. Repair by Dissecting Lower End of Duct from Pancreas and End-to-End Anastomosis

	NUMBER	PER CENT
Total cases	27	
Postoperative deaths	1	
Cases for study		
Excellent results	3	
Good results	10	73
Secondary operation on bile ducts	6	
Unsatisfactory results	7	
Total cases for study	26	

the duct. Satisfactory end-to-end anastomosis could not be made and a tube of rubber, vitallium or bouncing clay was used to bridge this gap. In these 6 cases, 5 were unsatisfactory. For the entire group of 27 cases, 73 per cent obtained a good result. It must be emphasized again and again that when this method is em-

Table 8. Plastic Operation for Stricture of the Bile Duct (Heineke-Mikulicz Method) from 1940 to 1948

	NUMBER	PER CENT
Total cases	17	
Postoperative deaths	1	
Cases for study		
Excellent results	6	100*
Good results	6	
Secondary operation on bile duct	4	
Total cases for study	16	

* Of those studied 12, or 75%, obtained good results after one operation.

Table 9. Dilatation and Tube Implantation from 1940 to 1948

	NUMBER	PER CENT
Total cases	41	
Postoperative deaths	1	
Cases for study		
Excellent results	11	80*
Good results	19	
Secondary operation on bile duct	2	
Unsatisfactory results	8	
Total cases for study	40	

* Of those studied 30, or 75%, obtained good results after one operation.

Table 10. Biliary-Intestinal Anastomosis (Jejunum and Duodenum) from 1940 to 1948

	NUMBER	PER CENT
Total cases	45	
Postoperative deaths	3	6.6
No follow-up	1	
Cases for study		
Excellent results	10	73.1*
Good results	16	
Secondary operation on bile duct	4	
Unsatisfactory results	11	
Total cases for study	41	

* Of those studied 26, or 63.4%, obtained good results after one operation.

ployed, if one hopes to obtain good results, complete duct continuity must be established without any degree of tension. If a defect exists in any part of the end-to-end anastomosis, if the anastomosis must be made under any tension, or if there is a considerable discrepancy in the caliber of the proximal and the distal duct (the proximal large and the distal small), this method should be abandoned

and a biliary-intestinal anastomosis performed. As demonstrated by this experience and these figures; the outcome will otherwise be unsatisfactory.

From a study of Table 8 which shows the results with the plastic operation (Heineke-Mikulicz type) as the initial procedure, it can be seen that in 16 out of 16, good results were achieved. The majority of the strictures treated by this method, which consists of longitudinal incision of the stricture followed by transverse closure with a T-tube implanted through a separate choledochostomy, were partial or very short strictures, the result often of clamp, crush, or narrowing of a sutured duct.

In the group of cases which were managed by simple dilatation and T-tube implantation, the results were good in 80 per cent of the cases (Table 9). In this group are included the 24 cases of fibrosis of the sphincter of Oddi.

Table 10 represents the results in those cases in which a biliary intestinal anastomosis was performed as the primary procedure. Satisfactory results were obtained with this type of procedure in 73.1 per cent of the cases in which it was employed. In the majority of these cases the proximal duct was anastomosed to a

Table 11. Defect Bridged by Tubes from 1940 to 1948

	NUMBER	PER CENT
Total cases	10	
Postoperative deaths	0	
Excellent results	0	
Good results	2	20
Unsatisfactory results	8	

long antecolic loop of jejunum and an entero-enterostomy was placed below the biliary intestinal anastomosis Although the results with this method (73.1 per cent) are nearly as good as those obtained with end-to-end anastomosis (78 per cent), this method does not preserve the sphincter mechanism of the ampulla which is so important in preventing regurgitation and recurrent episodes of cholangitis. In our hands, however, this plan has been the method of choice when satisfactory duct-to-duct anastomosis has been impossible and has as well been an expedient method for an extremely poor risk patient, or for the patient who would not tolerate a long and trying operative procedure well.

From 1940 to 1948 defects between the ends of the proximal and distal portions of an anastomosis were bridged by tubes in 10 cases (Table 11). The results were good in only 20 per cent of the cases. This procedure should, we believe, take its place with the operation of transplantation of an external fistula as an unsatisfactory procedure since neither of these methods offers the patient an adequate chance for a satisfactory and lasting result.

In the period from 1940 to 1948 external fistulas were created in only 3 cases. The results were unsatisfactory in all 3 cases. In these cases no duct whatever, either common or extrahepatic, could be found because of the extensive nature of the stricture and scarring, the results of previous attempts at repair before the patient came to us, and this measure has been employed as a last resort maneuver. It is well, however, to remember that occasionally it may be necessary to introduce a tube temporarily into the proximal duct (hepatic) in the extremely ill

patient, or in the patient who has a purulent cholangitis. This will serve to decompress or drain the liver and, following the improvement obtained by this procedure, a reconstruction or duct to jejunum anastomosis may be undertaken. There have been 2 instances in the past year in which this plan has been employed.

COMPLICATIONS

Because these results are more satisfactory than one might expect we would not have anyone believe that reconstructive surgery of the bile duct is not without its depressing complications, fatal and nonfatal. The nonfatal complications increase the morbidity of these cases materially and these surgical procedures are unavoidably trying from the point of view of both the patient and the surgeon.

In Table 12 are listed the fatal complications in the two periods under study, that is 1917 to 1939 and 1940 to 1948. There were 12 postoperative deaths in

Table 12. Fatal Postoperative Complications

	48 cases, 1917 to 1939	181 cases, 1940 to 1948
Liver failure	2	3
Hemorrhage	5	2
Sepsis	0	3
Bile peritonitis	2	0
Hepatorenal syndrome	1	1
Shock	1	1
Empyema	1	0
Cerebrovascular accident	0	1
Undetermined	0	1
	12	12

each of the two periods. During the period from 1917 to 1939 the leading cause of death was hemorrhage, and this accounted for 5 of the 12 deaths, whereas from 1940 to 1949 only 2 patients died as a result of hemorrhage postoperatively. This difference is explainable on the basis of a single factor, vitamin K. This vitamin was not available in the period from 1917 to 1939. The second important factor accounting for postoperative deaths in the two periods was liver failure. We now have a very much better understanding of the importance and method of preparing a patient with a badly damaged liver for surgery than we did in this era. The medical services are now responsible for preparing these patients for surgery by means of an intensive liver regimen. This regimen includes the dietary measures of supplying the patient with a palatable high protein, high carbohydrate, low fat (40 gm.) diet. To this diet are added all the vitamins, particularly C and B complex. In addition, oral and intravenous protein feedings are given, choline is added and crude liver given intramuscularly daily. Finally, the necessary blood transfusions are given to bring the patient's blood picture to as near normal as possible before operation. On this program most of these patients are able to tolerate these extensive procedures which at times are long and during which the blood loss may be serious.

The next most frequent fatal complications in these two periods were sepsis and peritonitis. It is important to note in the period from 1940 to 1948 that 3 patients died of sepsis. These deaths occurred in the earlier years of this series before we had the benefits of large amounts of penicillin and streptomycin. As stated earlier in the paper in the two years 1947 and 1948 there was but 1 postoperative death in 71 patients operated upon for strictures of the bile duct and this was caused by liver failure and postoperative shock.

The nonfatal complications have been listed in Table 13. There were a great many more complications listed for the period 1940 to 1948, during which time

Table 13. Nonfatal Postoperative Complications

	48 CASES, 1917 TO 1939	181 CASES, 1940 TO 1948
Extrusion of T-tube	0	11
Proximal arm of T dislodged by drain	0	2
Nonfatal hemorrhage	4	8
Hepatitis and cholangitis	1	8
Subhepatic abscess	2	3
Subdiaphragmatic abscess	0	3
Pelvic abscess	0	5
Peritonitis	0	3
Empyema	0	1
Wound infection	0	12
Gas bacillus infection	0	1
Wound evisceration	0	2
Partial separation	0	2
Intestinal fistula	0	4
Atelectasis	1	7
Bronchopneumonia	1	3
Pulmonary infarct	0	2
Pleurisy right base	0	2
Thrombophlebitis	0	3
Shock	1	2
Acidosis secondary to bile loss	0	3
Severe febrile reaction—etiology not determined	0	4
Psychosis	1	2

273 operative procedures were carried out on 185 patients. Prior to 1940 it was our plan to restrict the dissection of the right upper quadrant largely to the immediate area of the bile ducts, thereby making the operation almost extraperitoneal. This plan has been changed in the latter years to one by which the dissection of the right upper quadrant is quite complete, restoring all of the anatomy to as near normal as possible before the search for the divided duct is begun. This method has postoperative disadvantages because it opens up the general peritoneal cavity and leads to accumulations of serum, bile, and purulent material in the pelvis, under the diaphragm and under the liver. It does, however, permit anatomical visualization of all of the important structures here such as portal vein, hepatic artery, and the duct remnant. The frequency of these complications may be seen in Table 13.

Wound infections have not been uncommon. However, if gauze drapes are used and applied early, and if these drapes are made so that a sheet of cellophane

is incorporated between the layers of the gauze (F.H.L.), thus making the wound drape impervious, this complication will be less frequent. This complication, wound infection, occurred twelve times in 273 operative procedures. The use of steel wire in the last two years has definitely lessened the incidence of serious wound complications.

The bleeding tendency of these patients with prolonged jaundice and severe liver damage must obviously be treated vigorously with vitamin K preparations for prolonged periods before and after operation, as well as with fresh blood transfusions. Nonfatal hemorrhage occurred eight times in this series of cases.

T-tubes are used frequently in the reconstructive surgery of the bile duct. When the T-tube is dislodged or accidentally pulled out during the postoperative period, the patient is faced with the prospect of a recurrence of the stricture and further operation will be required regardless of how well the anastomosis has been made between the divided ends of the duct. The majority of these tubes have been pulled out while the patient sleeps and unconsciously rolls from side to side in bed. We are now placing the free end of the T-tube into a small asepto syringe which is strapped to the patient's dressing, and the distal end of the asepto syringe is attached to the drainage system. The T-tube is held to the abdominal wall by a piece of silk tied to the T-tube and to a safety pin and the safety pin is strapped to the abdominal wall adjacent to the incision (Figs. 291 and 292). This plan of management of the T-tube, suggested by C. E. Sedgwick in this clinic, provided a great added measure of safety during the postoperative management of these tubes. It does have the disadvantage that the tube not infrequently is pulled out of the asepto syringe and soils the sheet but this is better than pulling the tube out of the wound.

Not infrequently these patients will have an exacerbation of their jaundice with high fever immediately after surgery and little bile will drain from the implanted T-tube. This has been interpreted as hepatitis with cholangitis and we have treated these patients vigorously with large doses of penicillin and streptomycin.

As may be seen from Table 13 pulmonary complications are relatively frequent. These patients are encouraged to take breathing and leg exercises and they should be turned frequently. When serious atelectasis occurs it becomes immediately necessary to do tracheal aspirations with a catheter or by bronchoscope. Early ambulation is individualized for each patient; if they are vigorous they are allowed out of bed on their second or third postoperative day; if they have been chronically ill with serious jaundice ambulation is delayed. We would mention, finally, that the blood chemistry findings must be carefully followed in these patients. The loss of bile from an implanted T-tube may be great. Large quantities of sodium may be lost with serious acidosis as a result. The electrolytes lost in the bile must be replaced by the ordinary saline and glucose solutions as well as by applying calculated amounts of balanced solutions such as Hartmann's or one-sixth molar lactate solution.

SUMMARY

From an analysis of this quite complete follow-up study of our cases, we feel that we have established to our satisfaction that the principle of re-establishing

bile duct continuity by end-to-end anastomosis and in this manner preserving the sphincter of Oddi is a sound one.

From this same study we have satisfied ourselves that it is feasible in most of the patients coming to us for repair to isolate uninjured segments of the common duct by finding the intrapancreatic portion of the common duct and thereby accomplish end-to-end anastomosis with good results.

This study has shown that anastomoses of the stump of the hepatic duct to the jejunum may be accomplished in those patients in whom an end-to-end anastomosis is not feasible and a quite satisfactory end result anticipated.

This study has served to prove that it is unwise in terms of an expected satisfactory result to bridge duct defects by any type of tube to preserve continuity of the bile ducts.

Finally, a patient who has had an injury to his bile duct will have the best chance for a permanently good result if the initial repair is done at the time of injury or as soon after the injury as possible and if it re-establishes the continuity of the bile ducts and preserves the sphincter. If this is not accomplished and recurrence of the stricture takes place, the patient then is faced with at least one or two operations, a badly distorted operative field, and the chance for a permanently good result will diminish with each additional surgical procedure.

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THE SPLEEN, ADRENAL GLAND AND PANCREAS

SPLENECTOMY: WHEN IS IT INDICATED?

FRANK H. LAHEY AND JOHN W. NORCROSS

The subject, when is splenectomy indicated, is automatically divided into three different aspects. The first is the surgical removal of the spleen for conditions directly related to the spleen itself, such as tumors, ptosis, rupture or cyst, to increase radicalness in total gastrectomy or to aid exposure in operations in the left upper quadrant. Secondly, there are those states which have to do with splenic effects upon the peripheral blood cells or upon the bone marrow and the production of red and white blood corpuscles as well as platelets. Finally, there is a third division in which the indications for splenectomy are less well established in terms of lasting benefit from it. This includes the early cases of congestive splenomegaly, and the patients in whom the splenomegaly is of unknown origin and for whom the question arises as to whether or not splenectomy would be valuable as a prophylactic against possible later splenic effects.

GROUP I

Tumors and Cysts of Spleen. The tumors of the spleen, such as lymphosarcoma and Hodgkin's disease that are rarely but occasionally limited, at least in the beginning, in their involvement to the spleen, require no discussion, particularly when it is realized, as will be discussed in a later section dealing with splenic effects on bone marrow and blood, that at any time true tumors of the spleen or infiltration of the spleen as a part of the disease known as Gaucher's disease or inflammation of the spleen can promote secondary bone marrow and blood cell effects, producing the blood condition known as hypersplenism. This secondary splenic effect, associated with tumors and inflammatory processes in the spleen, results in depression of blood platelets, depression of granulocytes and depression of red blood cells. If such splenomegaly results in this state, panhematocytopenia, there can be no reasonable disagreement regarding the wisdom of splenectomy.

We have had 4 true cysts of the spleen. Since these in no way are difficult to manage, it can be assumed that the indications for splenectomy in these states are likewise accepted by everyone, particularly when such cysts attain significant size.

Wandering Spleen. The wandering spleen with which we have had but one experience, subject as it occasionally is, to torsion, likewise falls into the group for splenectomy, about which there would be no debate.

Rupture of Spleen. Trauma to the spleen, resulting in rupture and hemorrhage, likewise requires very little discussion. Located, as the spleen is, in the left upper quadrant and possessing, as it does, a definite pedicle also with quite inadequate fixation attachments to the posterior parietal wall of the abdomen, the

Originally published in Annals of Surgery, 128:363–376 (Sept.) 1948. J. B. Lippincott Co., publishers.

spleen is subject to injury following any trauma to the left upper quadrant. This may occur even when an indirect force to the pedicle of the kidney results in transmitted effects on the splenic vein and artery as they pass from the tip of the pancreas into the hilum of the spleen.

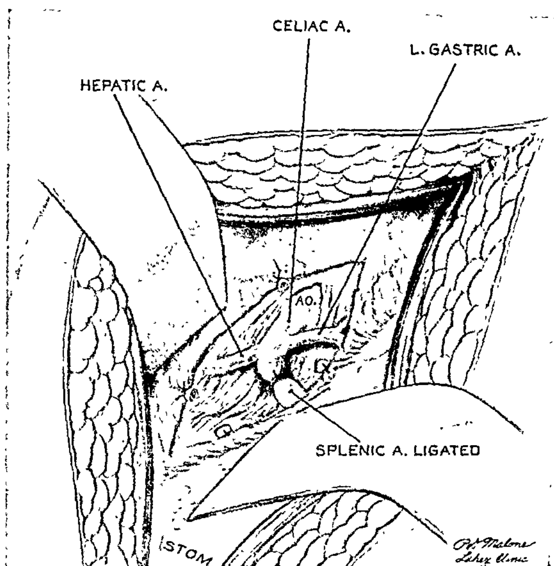


Fig 293. This illustration shows the preliminary ligation of the splenic artery close to its origin through the gastrohepatic omentum. This plan of controlling the arterial blood supply to the spleen close to the origin of the splenic artery is valuable, as discussed in the text in those large spleens difficult to displace and in those spleens, limited in number, with perisplenitis in which splenectomy is contemplated.

There is little that need be said regarding the indications for splenectomy in rupture of the spleen except to recall that force or injury which results in rupture of the spleen is delivered also to the pedicle of the kidney. In splenectomies done for ruptured spleen one should always be sure that there is not present also an injury to the underlying kidney.

The type of splenectomy which is done upon ruptured spleen is quite different from the deliberate approach to the pedicle of the spleen when splenectomy is undertaken for splenic effects upon the bone marrow or upon peripheral blood cells as shown in Figure 294. Since the patient will be in a state of relative emer-

gency, the less elegant but much more time-saving procedure of freeing the spleen from its peritoneal attachments by means of separating it bluntly with the finger, turning the entire spleen upward and inward together with the tail of the pancreas (Fig. 295) and ligating or clamping the splenic blood supply at once, will

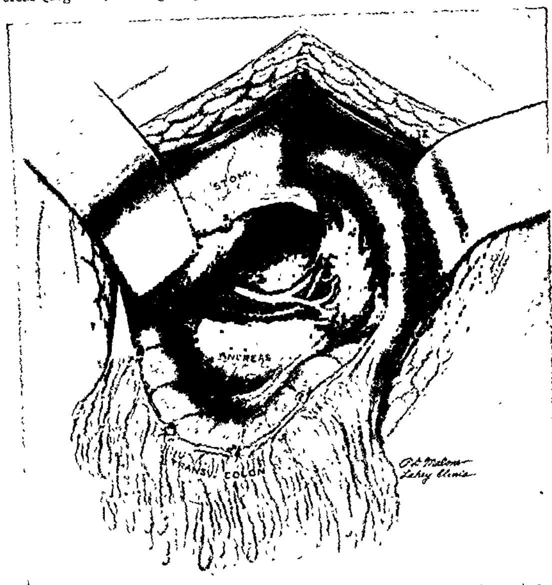


Fig. 294. This illustration shows the most satisfactory approach to the vascular pedicle of the spleen by wide exposure through the gastrocolic omentum. As stated in the text, by means of this exposure, accurate control of the blood supply to the spleen is obtained and it is possible to make very adequate searches for accessory spleens.

This method of approach was described and illustrated by Dr. Albert O. Singleton, and undoubtedly is employed by many surgeons.

give immediate control of bleeding, lessen the amount of blood loss, and shorten the time required to do the operation.

With the spleen out, it is not difficult to visualize the kidney region and determine whether or not there has been coincident injury to the renal vessels or to the kidney itself.

To Aid in Exposure and Increase Radicalness in Operations in Left Upper Quadrant. There is still another group of cases in which in recent

years we have employed splenectomy. This group includes the cases in which splenectomy, together with omentumectomy, is included in the operation of total gastrectomy in order to make the anastomosis of the jejunum to the esophagus easier, but primarily to increase the radicalness of total gastrectomy when done

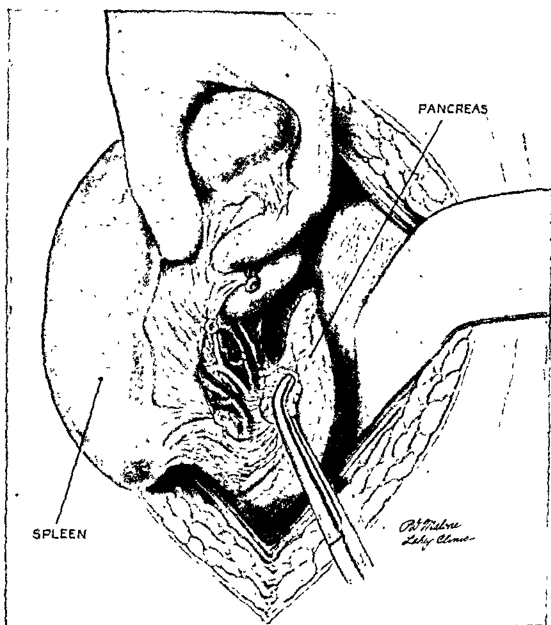


Fig. 295 This is the standard method for accomplishing splenectomy rapidly by means of which the spleen is bluntly freed from its peritoneal attachments, turned forward into the wound, the tail of the pancreas wiped off and its pedicle controlled by clamps, mass ligature or individual ligature.

for early or extensive gastric malignant disease. We have employed splenectomy in about half of the 100 cases of this type in which we have done total gastrectomy.

It will be recalled that in most of the patients for whom total gastrectomy is employed, that is, those with lymphoma of the stomach, those with leiomyosarcomas involving most of the stomach, or those with carcinoma of the stomach

of the linitis plastica type infiltrating usually a good part of the walls of the stomach, the malignancy as a rule involves all of the greater curvature and frequently runs upward to the entrance of the esophagus into the stomach. It is obvious that if the spleen be left behind and separated from the stomach by the ligation of the vasa brevia, there will be a section of omentum left behind attached to the spleen, there will be a severing of the blood supply along the upper part of the greater curvature of the stomach quite close to the gastric malignancy, and that by the removal of the spleen and not part but all of the omentum, a much more radical and extensive removal of the malignancy with a wider area about it can be accomplished. For this reason we believe that splenectomy, since it is apparently harmless from our experience with this good sized series of cases in which it has been added to total gastrectomy, is a very desirable procedure to employ in this condition.

There will be other conditions, such as transthoracic resection of the lower esophagus and cardia, also certain patients with diaphragmatic hernia in whom the spleen has migrated into the intrapleural hernia sac, and certain cases of diaphragmatic hernia, repaired from below, in which the removal of the spleen will make the exposure of the diaphragm and suture of the hernia in it much easier. There will even be cases of high ulcers of the lesser curvature in which, by removal of the spleen, a section of stomach can be so rotated downward that the high lesser curvature ulcers close to the esophagus can be removed and an adequate amount of stomach made available by this exposure and rotation to make it possible to do a partial gastrectomy rather than a total gastrectomy. In addition to this, there will be a few diverticula of the stomach high on the greater curvature in which removal of the spleen will make exposure and management of these lesions easier.

GROUP II

It is not as easy to discuss those indications for splenectomy which are related to what has been called the effects of hypersplenism upon the bone marrow and the peripheral blood cells, since hypersplenism may be either primary and of unknown etiology, as in idiopathic thrombocytopenia, idiopathic neutropenia or hemolytic anemia, or secondary as the result of invasion of the spleen by tumor, inflammation or even associated with the splenomegalies of congestive splenomegaly. Those states are in addition much more complex as to the indications for splenectomy since many of the blood states which are caused by hyperspleens can and sometimes are brought about by toxic substances, certain drugs and some metabolic disturbances.

There is an important relationship existing between the spleen and the reticulo-endothelial system on the one hand and the bone marrow on the other. The spleen normally inhibits the bone marrow so as to exert a controlling influence on the output of blood cells produced by it. Under certain circumstances, this delicate balance is disturbed and the spleen may overinhibit the various cell-forming functions of the bone marrow or it may destroy cells more rapidly than it normally should. In some cases there is a combination of these two factors at play. These mechanisms are the basis for the indications for splenectomy in certain hematologic abnormalities.

It can no longer be said that there are only two clear-cut medical indications for splenectomy, namely congenital hemolytic anemia and idiopathic thrombocytopenic purpura. We must now add further medical indications: selected cases of acquired hemolytic anemia, idiopathic neutropenia, primary splenic panhematocytopenia, selected cases of secondary splenic panhematocytopenia, selected cases of congestive splenomegaly, and selected cases of splenomegaly of unknown origin (Table 1).

Congenital Hemolytic Anemia. The *hereditary abnormality in this disease* leads to a change in many of the adult red blood cells by which they are small in diameter but thicker than normal. These spherocytes are removed by the reticulo-endothelial system, of which the spleen is an important part, and their

Table 1. Indications for Splenectomy

GROUP I	
	1. Rupture of the spleen
	2. Wandering spleen
	3. Primary splenic tumors
	4. To aid in exposure and radicalness in operations in left upper quadrant
GROUP II	
	1. Congenital hemolytic anemia
	2. Acquired hemolytic anemia (selected cases)
	3. Idiopathic thrombocytopenic purpura
	4. Idiopathic neutropenia
	5. Primary splenic panhematocytopenia
	6. Secondary splenic panhematocytopenia (selected cases)
GROUP III	
	1. Congestive splenomegaly (selected cases)
	2. Splenomegaly of unknown origin (selected cases)

destruction leads to evidence of increased hemolysis with an increased output of urobilinogen in the urine and feces and hyperbilirubinemia. The anemia resulting from the destruction of red blood cells stimulates the bone marrow, which becomes overactive, the hyperplasticity being normoblastic in type. The reticulocytes in the peripheral blood are increased.

Splenectomy stops the greater part of this blood destruction, although it does not change the abnormality leading to the spherocytosis. If care is taken to *remove accessory spleens, it is rare to have any return of anemia or jaundice.* It is in this condition that splenectomy is most uniformly followed by good hematologic results.

We have had 20 such cases in the period from 1934 to 1947. There were no operative deaths. Three accessory spleens were found and removed in this series. *Pigment gallstones were present in 25 per cent of the cases. Splenectomy* resulted in complete cure of the anemia in 90 per cent of the cases and marked improvement in the other 10 per cent.

Acquired Hemolytic Anemia. This condition may be acute or chronic and may be secondary to a large number of diseases. The most important of these

are: chemical toxins such as benzol, some parasitic diseases as malaria, certain bacterial infections, some cases of malignancy as leukemia, and idiopathic types in which abnormal agglutinins and hemolysins may be found. It is often impossible to predict whether splenectomy will be of any value in these cases. In general, it should not be done in malignancy, infections or parasitic disease. Rarely, a severe hemolytic anemia in a very chronic lymphatic leukemia might be benefited by splenectomy. Acute hemolytic anemia of the acquired type often responds favorably to splenectomy but does not always do so. The chronic hemolytic anemias demand detailed individual study and in selected cases removal of the spleen may prove beneficial. Results are uncertain, although occasionally spectacular. It should generally be considered the procedure of last resort in these conditions.

We have operated on 6 such patients (1934–1947), with no operative deaths but with excellent results in only 1.

Idiopathic Thrombocytopenic Purpura. This hemorrhagic disease of unknown origin must be carefully distinguished from thrombocytopenic purpura of known cause. All drug contacts must be scrutinized and allergic phenomena considered. It is essential to study the bone marrow where the megakaryocytes in the idiopathic type will be plentiful and will show little platelet formation at their periphery. Bone marrow study will also rule out infiltrating disease, such as leukemia, which may cause thrombocytopenia by replacement. If the eosinophils are markedly increased, allergic types of thrombocytopenia must be suspected. If these precautions are strictly observed and the studies indicate a truly "idiopathic" type, results of splenectomy will be good. However, under the best of circumstances relapses will occur, sometimes many years after operation.

The response to splenectomy is usually immediate but cases have been observed in which it was delayed and slow, although eventually adequate. The increased capillary fragility, prolonged bleeding time and low platelet count rapidly become normal and the purpura disappears. About 75 per cent of patients who undergo splenectomy for this condition remain permanently cured. In acute fulminating cases, splenectomy must be done as an emergency in order to avoid hemorrhage into vital organs. The discovery and removal of accessory spleens are of particular importance in this condition because if thrombocytopenic purpura should occur at a later date, the uncertainty of finding splenic tissue at operation makes any surgical procedure so dangerous as to be prohibitive. We have had 17 cases of this type with no operative mortality. Recurrences have taken place in 3 cases (17.6 per cent) and in 2 cases the response of the platelets was slow but eventually good. The other patients all responded rapidly and apparently permanently.

In patients with hemolytic anemia or with idiopathic thrombocytopenic purpura, once splenectomy has been settled upon it should be carried out without undue delay to avoid the occurrence of a critical state which can arise during the delay interval.

Idiopathic Neutropenia. In certain cases when the balance between bone marrow and spleen is upset and the normal inhibitory effect of the spleen is enhanced, the granulocytes alone may be affected, leading to a neutropenia.

As in the other hematologic conditions already discussed, careful study of these cases is essential to rule out other known causes of neutropenia, such as drug and other chemical contacts, aleukemic leukemia, lymphoblastoma, and various infections. Again, the bone marrow picture will help to rule out these secondary causes of neutropenia and in the idiopathic type will be normal or will show a hyperplasia of the granulocytic cells with little change in the other elements.

It has only been in recent years that this disease has been established as a definite entity and now takes its place as another form of hypersplenism. The response to splenectomy is immediate and although enough time has not elapsed fully to evaluate this procedure, results appear to be long lasting.

Primary Splenic Panhematocytopenia. This form of hypersplenism involves all of the main cellular elements of the bone marrow and results in neutropenia, anemia and thrombocytopenia. The etiology of this syndrome is not known. Both congenital and acquired types have been described. Bone marrow studies in either type demonstrate hyperplasia involving the red cells, granulocytic and megakaryocytic elements. When the enlarged spleen is removed, there is a rapid return to normal hematologic values in the peripheral blood. Some cases are acute and require emergency splenectomy, while others are chronic and gradually become severe enough to require repeated transfusions to sustain life. Splenectomy is indicated in all cases of this syndrome when care has been taken to exclude known causes for panhematocytopenia.

Secondary Splenic Panhematocytopenia. A decrease in neutrophils, platelets and red blood cells in the peripheral blood may be secondary to a number of disease processes. In some way, as yet not understood, a spleen that is involved in almost any disease and becomes enlarged, particularly if the disease be of any lasting nature, may become hyperactive and exert an abnormal inhibiting effect on the cells of the bone marrow with or without an added increase in the destructive processes carried on by the spleen. For instance, Hodgkin's disease may be first discovered in this form when the spleen alone is involved and when the blood picture is only indirectly caused by the underlying disease coming as it does from a diseased spleen. Other forms of lymphoblastoma, chronic malaria, rheumatoid arthritis, congestive splenomegaly, sarcoidosis, tuberculosis, Gaucher's disease and certain drug sensitivities as in some cases of benzol poisoning, are all examples of the etiologic factors that may cause this syndrome.

Selected patients in this group respond well to splenectomy, the selection depending on the type of primary condition underlying the process, the severity of the hematologic abnormality, and the probable duration of life in the primary disease. Patients suffering from Hodgkin's disease with secondary hypersplenism of this panhematocytopenic type may rarely have no other manifestations of the disease for long periods of time and under such circumstances splenectomy is justified. This type of problem taxes the physician's judgment severely and it is sometimes impossible to judge whether the duration of life after splenectomy will be long enough to justify the procedure.

We have had 7 cases of splenic panhematocytopenia. There has been no operative mortality in this group. The hematologic results have been excellent in 4, good in 1 and fair in 2.

GROUP III

Under the third group comes congestive splenomegaly and the splenomegalies of unknown origin.

Congestive Splenomegaly. This condition arises whenever there is a partial or a total obstruction in the splenic vein or any portion of the portal system at or above the level of the splenic vein. Such obstruction results in hypertension within the portal system behind the obstruction and to an engorged collateral circulation that often menaces life by severe hemorrhage into the stomach or esophagus. The most common site of portal obstruction is within the liver itself and is the result of cirrhosis. Other less common etiologic factors in this syndrome are congenital abnormalities of the portal system, rare cases of Schistosomiasis mansoni and thrombosis of the splenic vein. When portal cirrhosis is the primary factor, hepatic failure or hemorrhage from varices may be the terminal event.

In addition to the danger of hemorrhage from varices, the enlarged spleen often eventually leads to panhematocytopenia with its bad effect on the general well being of the patient. Banti originally implied that a splenic hormone was to blame for the liver cirrhosis in these cases and this theory has never been completely disproved. Careful evaluation of the patient with this syndrome is essential and a decision for or against splenectomy is often difficult to make. In general, it should be said that any patient with congestive splenomegaly should have the enlarged spleen removed if he is able to stand the operative procedure. By this means, from 25 to 40 per cent of the blood entering the portal circuit can be removed and the hypersplenic effects of the enlarged spleen abolished. Unfortunately, we often see these patients only after they are far advanced in their disease, and they are often desperate risks. Only after extensive study of the liver function, prolonged medical preparation, and careful weighing of the pros and cons in the individual case can a decision be reached. If we are to help more of these patients, it is necessary that we see them before the late phases of the disease when liver function has been so badly damaged, varices so widely established and secondary hematologic changes so far advanced.

Splenectomy should be performed as soon as the diagnosis has been established and the condition of the patient permits We have had 25 cases of congestive splenomegaly in this series (1934 to 1947); there have been 2 operative deaths, a mortality of 8 per cent. These represent the only operative deaths in the entire series. Postoperative complications are frequent and vary from many types of infection to liver failure.

Of the 14 patients who had gastrointestinal bleeding preoperatively, 12 could be followed postoperatively and 3 of these had recurrent hemorrhage, 1 eight months after operation, 1 three and one quarter years after operation and 1 three and three quarter years after operation. The course of the remaining 9 patients was followed from three months to seven years with an average follow-up of twenty-six months, and they had no postoperative bleeding. Hematologically, the results have been uniformly good with return to normal blood values.

Splenomegaly of Unknown Origin. Routine careful physical examination will uncover a considerable number of cases of unexplained splenomegaly in

and a number will remain unexplained after exhaustive study is completed. If, after six months' observation, the spleen enlarges or remains unchanged and the cause is still unknown, it should be removed. In the temperate zones many cases of early congestive splenomegaly will be discovered in this way, and when removed at this stage will greatly delay or entirely prevent the development of varices. Some examples of malignant tumors primary in the spleen will be found and occasionally removed before spread to other parts of the body has taken place. Removal and study of these spleens undiagnosed before operation will do much to increase our knowledge of this organ, its pathology and its pathologic physiology. It is understood, however, and this point cannot be overemphasized, that splenectomy must never be performed until all studies have been exhausted in attempting to make a diagnosis and above all, a sincere effort made by a competent observer to rule out definite contraindications to splenectomy.

CONTRAINDICATIONS

It is essential that the spleen not be removed in cases of agnogenic myeloid metaplasia because in this condition much of the bone marrow function of forming blood cells has been transferred from the bone marrow to the spleen and removal of this organ may be rapidly fatal. Competent hematologic study and bone marrow observation will quickly establish this diagnosis and any thought of splenectomy must be dismissed. With rare exceptions, splenectomy in cases of leukemia and lymphoblastoma with splenomegaly should be avoided. The exceptions include rare panhematocytopenias or hemolytic anemias of severe degree caused by hypersplenism in some of these cases. They also include cases in which the disease may still be limited to the spleen but such cases are very rare indeed. The spleen should not be removed in polycythemia vera although rarely a case is seen in which the influence of the enlarged spleen is such as to inhibit the output of a normal number of cellular elements. It is most unusual to find splenomegalies in infections in which splenectomy is justified, although rarely the hypersplenic effect is such as to demand careful consideration of this procedure. In general, patients with paroxysmal nocturnal hemoglobinuria do poorly after splenectomy and patients with Mediterranean and sickle cell anemias are also not helped by the procedure.

The technical complications of splenectomy in patients with congestive splenomegaly in which marked perisplenitis exists are of such seriousness and the benefits so problematical as to contraindicate its employment when this state is found.

COMPLICATIONS

The complications of splenectomy are hemorrhage, thrombosis and infection. Hemorrhage may arise from the surgical bed if a vessel comes loose or it may arise from a general oozing secondary to severe liver damage and a resulting hypoprothrombinemia This complication sometimes follows splenectomy for congestive splenomegaly associated with severe liver damage and is of bad prognostic significance. Thrombosis occurs more readily after splenectomy than after other surgical procedures because of the rapid and excessive rise in platelets

that occurs immediately following operation. Careful observation of the platelet count and the institution of anticoagulant therapy in certain cases will reduce this complication to a minimum. Infection of various types may follow splenectomy particularly in cases of congestive splenomegaly associated with severe liver damage, and in these cases modern potent antibiotics should be used prophylactically. Liver failure may follow and attempts should be made to anticipate this with present day methods.

Table 2 demonstrates the frequency of complications in congestive splenomegaly as compared to other reasons for splenectomy. Table 3 shows the type of complications encountered in our series.

TECHNICAL CONSIDERATIONS

Many methods of doing splenectomy have been developed and published but in general the approach to splenectomy divides itself again into three distinct

Table 2. Frequency of Complications of Splenectomy
(1934–1947)

Congenital hemolytic anemia (20 cases)	1
Idiopathic thrombocytopenic purpura (17 cases)	3
Acquired hemolytic anemia (6 cases)	2
Congestive splenomegaly (25 cases)	19
Cysts (4 cases)	0
Miscellaneous (4 cases)	0
Total	25

Table 3. Type of Complications of Splenectomy
(1934–1947)

Atelectasis	4
Subdiaphragmatic abscess	3
Thrombophebitis	4
Ascites	2
Hemorrhage from liver failure	3
Miscellaneous infections	7
Hemolytic crisis	1
Diarrhea (question of etiology)	1
Total	25

plans. (1) preliminary ligation of the splenic artery close to its origin, (2) the deliberate exposure of the splenic vessels along the upper edge of the pancreas and as they enter the hilum of the spleen by careful and accurate exposure, as shown in Figure 294, through the gastrocolic omentum and (3) the rapid method of freeing the spleen from its attachments to the lateral and posterior abdominal wall by blunt separation of the spleen from these peritoneal attachments with the fingers. Each of these technical approaches to splenectomy has advantages under different circumstances.

In the spleen of enormous size and in those with any degree of perisplenitis, the method shown in Figure 293 in which the splenic artery is ligated close to

and a number will remain unexplained after exhaustive study is completed. If, after six months' observation, the spleen enlarges or remains unchanged and the cause is still unknown, it should be removed. In the temperate zones many cases of early congestive splenomegaly will be discovered in this way, and when removed at this stage will greatly delay or entirely prevent the development of varices. Some examples of malignant tumors primary in the spleen will be found and occasionally removed before spread to other parts of the body has taken place. Removal and study of these spleens undiagnosed before operation will do much to increase our knowledge of this organ, its pathology and its pathologic physiology. It is understood, however, and this point cannot be overemphasized, that splenectomy must never be performed until all studies have been exhausted in attempting to make a diagnosis and above all, a sincere effort made by a competent observer to rule out definite contraindications to splenectomy.

CONTRAINDICATIONS

It is essential that the spleen not be removed in cases of agnogenic myeloid metaplasia because in this condition much of the bone marrow function of forming blood cells has been transferred from the bone marrow to the spleen and removal of this organ may be rapidly fatal. Competent hematologic study and bone marrow observation will quickly establish this diagnosis and any thought of splenectomy must be dismissed. With rare exceptions, splenectomy in cases of leukemia and lymphoblastoma with splenomegaly should be avoided. The exceptions include rare panhematocytopenias or hemolytic anemias of severe degree caused by hypersplenism in some of these cases. They also include cases in which the disease may still be limited to the spleen but such cases are very rare indeed. The spleen should not be removed in polycythemia vera although rarely a case is seen in which the influence of the enlarged spleen is such as to inhibit the output of a normal number of cellular elements. It is most unusual to find splenomegalies in infections in which splenectomy is justified, although rarely the hypersplenic effect is such as to demand careful consideration of this procedure. In general, patients with paroxysmal nocturnal hemoglobinuria do poorly after splenectomy and patients with Mediterranean and sickle cell anemias are also not helped by the procedure.

The technical complications of splenectomy in patients with congestive splenomegaly in which marked perisplenitis exists are of such seriousness and the benefits so problematical as to contraindicate its employment when this state is found.

COMPLICATIONS

The complications of splenectomy are hemorrhage, thrombosis and infection. Hemorrhage may arise from the surgical bed if a vessel comes loose or it may arise from a general oozing secondary to severe liver damage and a resulting hypoprothrombinemia. This complication sometimes follows splenectomy for congestive splenomegaly associated with severe liver damage and is of bad prognostic significance. Thrombosis occurs more readily after splenectomy than after other surgical procedures because of the rapid and excessive rise in platelets

that occurs immediately following operation. Careful observation of the platelet count and the institution of anticoagulant therapy in certain cases will reduce this complication to a minimum. Infection of various types may follow splenectomy particularly in cases of congestive splenomegaly associated with severe liver damage, and in these cases modern potent antibiotics should be used prophylactically. Liver failure may follow and attempts should be made to anticipate this with present day methods.

Table 2 demonstrates the frequency of complications in congestive splenomegaly as compared to other reasons for splenectomy. Table 3 shows the type of complications encountered in our series.

TECHNICAL CONSIDERATIONS

Many methods of doing splenectomy have been developed and published but in general the approach to splenectomy divides itself again into three distinct

Table 2. Frequency of Complications of Splenectomy
(1934–1947)

Congenital hemolytic anemia (20 cases)	1
Idiopathic thrombocytopenic purpura (17 cases)	3
Acquired hemolytic anemia (6 cases)	2
Congestive splenomegaly (25 cases)	19
Cysts (4 cases)	0
Miscellaneous (4 cases)	0
Total	25

Table 3 Type of Complications of Splenectomy
(1934–1947)

Atelectasis	4
Subdiaphragmatic abscess	3
Thrombophebitis	4
Ascites	2
Hemorrhage from liver failure	3
Miscellaneous infections	7
Hemolytic crisis	1
Diarrhea (question of etiology)	1
Total	25

plans (1) preliminary ligation of the splenic artery close to its origin; (2) the deliberate exposure of the splenic vessels along the upper edge of the pancreas and as they enter the hilum of the spleen by careful and accurate exposure, as shown in Figure 294, through the gastrocolic omentum and (3) the rapid method of freeing the spleen from its attachments to the lateral and posterior abdominal wall by blunt separation of the spleen from these peritoneal attachments with the fingers. Each of these technical approaches to splenectomy has advantages under different circumstances.

In the spleen of enormous size and in those with any degree of perisplenitis, the method shown in Figure 293 in which the splenic artery is ligated close to

THE CONTROL OF ACUTE AND CHRONIC PANCREATIC PAIN

KENNETH W. WARREN

Pain originating in the pancreas is frequently unrecognized and maltreated. When it is correctly diagnosed, it may, by virtue of its severity and persistence, present a real challenge in terms of therapy.

The rational management of pancreatic pain requires (1) a prompt recognition of its existence, (2) a correct assessment of its etiology, and (3) the availability and individual application of a variety of therapeutic measures designed to eliminate the pathologic process, if possible, or to afford symptomatic relief when definitive measures are unavailable or their application appears unduly hazardous.

Pancreatic pain lacks, to some degree, the sharp clinical characterization commonly observed in diseases of the stomach, duodenum and biliary tract, and yet with increasing knowledge in this field more precise clinical patterns are being recognized. Essential to this increasing clinical recognition of pancreatic disease is a constant awareness by physicians and surgeons alike of the possible existence of pathologic states involving this organ, coupled with more frequent application of direct and indirect tests designed to detect pancreatic disease. Despite the development and refinement of newer test for alterations in pancreatic function, and the high specificity of certain of the laboratory aids, the diagnosis of pancreatic disease will, in many instances, rest upon the elimination of other viscera, more accessible to clinical and laboratory study, as the source of the presenting signs and symptoms.

The location of the pancreas in the deeper recesses of the upper abdominal cavity, with its complex visceral, neural and vascular relationships, gives rise to symptom complexes which vary tremendously in their intensity, duration and degree of physiologic disturbance. The severe pain of acute pancreatic necrosis, for instance, will not be confused with the dull, insidious, intermittent distress of early carcinoma of the pancreatic body; nor will the recurrent progressive and frequently demoralizing pain of chronic relapsing pancreatitis suggest the presence of an uncomplicated cyst which may be entirely painless. In general, pancreatic pain tends to radiate to the left flank and back, to be aggravated by the ingestion of food and by recumbency, to be less responsive to relief by vomiting than gastric or biliary pain and to be diminished, in some instances, by sitting in an attitude of acute flexion.

ACUTE PANCREATITIS

The pain associated with acute pancreatitis may be relatively mild in the edematous phase of the disease, and may respond favorably to conventional

Originally published in Surgical Clinics of North America, 30 873–883 (June) 1950.

analgesics and to narcotics in average dosage. The severe, relentless pain, indicative of acute pancreatic necrosis, on the other hand, is singularly refractory even to large amounts of morphine. Indeed, it has been argued that morphine is contraindicated in acute pancreatitis, because this drug induces spasm of the sphincter of Oddi and thereby aggravates the pain. The utilization of large amounts of narcotics in the presence of major degrees of pancreatic disruption must likewise be condemned on the basis of its depressant effects in an already extremely ill patient. Despite these theoretical objections to the use of morphine in acute pancreatitis, it has been difficult in the past to withhold this drug, since other medicaments, advocated as substitutes, frequently have proved even less effective than morphine.

The mechanism of pain production in diffuse pancreatic necrosis is so complex that the therapeutic management must include a combined attack aimed at minimizing the diverse physiologic consequences of pancreatic disruption. Despite the many unknown factors relative to the etiology and progression of acute pancreatitis, it is reasonable to assume that these basic elements are operative in the average case, and that they combine to produce, or to aggravate, the characteristic pain; for example, (1) an obstructive factor which leads to (2) disruption of the acinar and ductal system, permitting (3) escape of activated pancreatic enzymes intraperitoneally and retroperitoneally. The migration of these necrotizing ferments (4) produces visceral and somatic pain from direct stimulation of nerve endings, and (5) leads to a secondary ileus which aggravates the abdominal distress. An awareness of these factors is requisite to the application of a thorough therapeutic plan in acute pancreatitis.

Gastric and Intestinal Siphonage. Gastric retention, associated with repeated vomiting, is an early and prominent feature in severe pancreatitis. An insidious and extremely persistent intestinal ileus follows. The prompt institution of continuous gastric and intestinal suction by way of Levin and Miller-Abbott tubes, respectively, is an important consideration in the management of the pain of acute pancreatitis. It is important to achieve intestinal intubation in the early phase of the disease, before the ileus becomes established, if the best results are to be obtained. The prevention, by continuous gastric suction, of repeated stimulation of the duodenal papillae by the progression of gastric acid through the pylorus may also minimize the obstructive tendency in the ampulla of Vater if it be present. Food should be withheld since its ingestion will stimulate pancreatic secretion.

Analgesics and Antispasmodics. In view of the theoretical objections to the administration of morphine in acute pancreatitis, it is preferable to attempt to control the pain by the utilization of antispasmodics such as nitroglycerin and atropine, in conjunction with demerol in liberal doses. Atropine may depress the acinar secretion and is theoretically superior to nitroglycerin in this instance. It is common experience, however, to find that these drugs are ineffectual in relieving the pain of acute pancreatic necrosis, and that one ultimately must resort to frequent administration of large doses of morphine in an effort to quiet the patient.

Splanchnic, Paravertebral and Epidural Procaine Block. The lack of an adequate drug for the control of the pain of acute pancreatitis has led to

speculation relative to more direct means of relieving the distress in this condition. Marion[8] has reported the relief of pain of acute pancreatitis by splanchnic anesthesia, and Gage[5] has employed both paravertebral and splanchnic blocks in pancreatic necrosis. Our failure to secure any consistent relief of pain in this disease with paravertebral injections of procaine recently led us (Orr and Warren[10]) to try continuous (fractional) epidural procaine analgesia (Fig. 296). The result was so gratifying that we believe this method should be employed in the severe varieties of the disease.

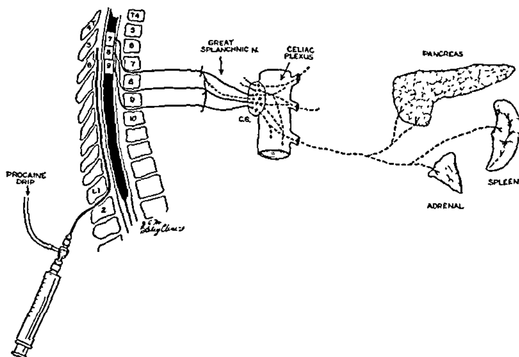


Fig 296. Position of catheter in epidural space in relation to origin of nerve supply to pancreas.

Technic. A special 16 G Huber pointed needle is inserted into the first lumbar interspace until the point meets the ligament. A 2 cc. syringe, filled with 1 per cent procaine solution, is attached to the needle and gentle pressure is made on the plunger while the needle is slowly advanced. When the epidural space is entered there is a sudden give to the plunger. The syringe is disconnected and the needle is carefully observed for any flow of spinal fluid. If no fluid escapes by simple gravity or can be withdrawn with a syringe, a No. 3½ French ureteral catheter is then threaded through the needle and advanced cephalad within the epidural space to the desired level (eighth thoracic segment of the spinal cord; Fig. 296). The needle is withdrawn and the catheter anchored to the skin with adhesive tape. Continuous analgesia is maintained by periodic or constant drip injection of a 2 per cent solution of procaine. In general, 5 cc. of solution is required each thirty minutes to allay the pain. The addition of epinephrine (1:100,000 dilution) to the procaine will reduce the procaine requirement about 50 per cent.

We have left the catheter in the epidural space for forty-eight hours, and see no serious objection to leaving it longer if necessary. The possibility of intro-

ducing infection into the epidural space will be minimized by the administration of penicillin and streptomycin, which drugs are indicated as well in the treatment of pancreatitis.

The severity and persistence of the pain of acute pancreatic necrosis contribute to the mental and physical exhaustion of the patient and demand heroic measures for relief. We believe that continuous epidural analgesia affords the most effective and least depressing means of controlling the pain of severe acute pancreatitis.

CHRONIC RELAPSING PANCREATITIS AND PANCREATOLITHIASIS

The pain in chronic relapsing pancreatitis varies according to the pathologic changes present in the gland, and ranges from intermittent mild distress in the presence of edema and early fibrosis to constant severe pain when hemorrhagic necrosis, cystic degeneration, abscess, calcification and stones occur. The demoralizing character of the pain in the late phases of the disease is reflected in the high incidence of alcoholic and narcotic addiction among the victims.

The control of the pain in the milder cases may be obtained in many instances by strict dietary management, eliminating all fried foods, raw fruits and vegetables and spices. Alcohol is poorly tolerated and should be avoided. During painful seizures morphine may be required if demerol is ineffectual. The hazard of drug addiction is considerable and should be borne in mind in determining the choice of analgesics. Severe episodic seizures may be relieved by an epidural procaine block. As the disease progresses, medical management may not be adequate and a variety of surgical procedures may be required.

During or following an acute exacerbation, solitary or multiple pancreatic cysts may appear. Their proper management will depend upon their location, duration, extent and the degree of associated inflammation. Some may respond to simple drainage or marsupialization. Others may be handled more advantageously by excision of the involved portion of the gland, including the cyst. Because of the chronicity and natural progression of the primary pathologic process in chronic relapsing pancreatitis, internal drainage of the associated cysts should not be performed except in unusual circumstances.

Considerable attention has been directed toward surgical measures designed to prevent the recurrence of the painful seizures associated with chronic relapsing pancreatitis. Gambill, Comfort and Baggenstoss,[6] who have contributed the most important clinical data referable to this disease, have found that the elimination of the coexisting disease of the biliary tract appears to prevent or minimize recurrent attacks in some instances. Others have advocated the by-passing of the ampulla of Vater on the biliary side by performing a choledochoduodenostomy or similar maneuver, designed to eliminate the reflux of bile into the pancreatic ducts wherein spasm or stenosis of the ampulla is demonstrated or suspected. Doubilet and Mulholland[3] believe that spasm or stenosis of the ampulla of Vater is a very important consideration in the etiology of chronic relapsing pancreatitis and have advocated transcholedochal sphincterotomy for the relief and prevention of the recurrent painful episodes. We have preferred, at this clinic, to preserve the integrity of the sphincter, where possible, and have advocated (Cattell[1]) the transcholedochus dilation of the sphincter, followed by prolonged

intubation by means of a long-limb T-tube which traverses the ampulla and prevents recurrent stenosis. *We have reserved sphincterotomy for those unusual* instances where the sphincter could not be dilated safely from above, and have, under these circumstances, resorted to transduodenal sphincterotomy, followed by prolonged intubation, utilizing the long-limb T-tube. In our experience in this clinic, chronic relapsing pancreatitis is not necessarily associated with a common pancreatobiliary channel or with stenosis of the ampulla of Vater. Nor, by the same token, is stenosis of the ampulla of Vater accompanied, in any considerable numbers, by chronic relapsing pancreatitis.

Despite these essentially conventional surgical measures designed to relieve and prevent the pain of chronic relapsing pancreatitis, there remains a significant number of cases which demands more radical surgical procedures, particularly in that group of patients in whom the disease is attended by pancreatic calculi or calcinosis.

Sympathectomy. Mallet-Guy and associates,[7] in 1945, reported 11 cases of chronic pancreatitis treated symptomatically by extensive splanchnicectomy. All were reported to have been relieved by resection of the left splanchnic nerves, but one patient suffered a recurrence of the pain five months after the operation. These operations were performed subdiaphragmatically at the time of abdominal exploration. Fontaine[4] and his co-workers, in 1946, reported one case in which splanchnic resection was performed for chronic pancreatitis. Smithwick,[13] in discussing Whipple's paper on pancreatectomy for calcareous deposits, related that he had performed a radical transthoracic resection of the sympathetic trunk on the right side, along with the greater splanchnic nerve on the same side. The patient was relieved of the pain. Rienhoff and Baker[12] reported combined radical sympathectomy and vagotomy for the relief of chronic pancreatic pain. De Takats and Walter[14] recorded 2 instances of unilateral splanchnicectomy performed for intractable pancreatic pain. Recently, Ray and Console[11] have related their experiences with extensive sympathectomy in this disease. They discussed the anatomical basis for the procedure and attempted to demonstrate that the operation on the sympathetic nervous system need not be as extensive as is generally practiced.

Unilateral and bilateral thoracolumbar sympathectomy and splanchnicectomy have been utilized for the control of the chronic pain of pancreatic lithiasis in the clinic with encouraging results in several instances, although the relief has not been complete in some cases. Recently Orr, of the Department of Anesthesiology, has tried epidural procaine blocks during recurrent episodes of pancreatic pain with promising results. We hope to evaluate the procedure of periodic epidural block further in selected patients before resorting to radical sympathectomy.

Pancreatolithotomy. *Calcareous deposits involving the pancreas are rarely* suitable for local removal by simple lithotomy. Calculi in pancreatolithiasis, even when confined within the ducts of the gland, are usually so numerous and frequently fused in such a manner within the smaller radicals that they cannot be successfully removed by transductal manipulation. Furthermore, a variable, often predominant, degree of parenchymal calcification accompanies the intraductal stones and contributes to the painful episodes. Pancreatolithotomy, there-

fore, is limited primarily to the removal of one or a few larger stones situated within the larger proximal ducts when acinar calcinosis is absent, and to the removal of residual intraductal collections in the pancreatic remnant at the time of partial pancreatic resection in the presence of combined pancreatolithiasis and diffuse pancreatic calcinosis.

Partial and Total Pancreatectomy. The decision to resort to partial or total pancreatectomy for the relief of the pain of chronic relapsing pancreatitis and for calcareous deposits involving the organ, must not be assumed lightly. Sincere attempts at medical management must be pursued. Associated gastrointestinal disease, especially involvement of the biliary tree and ampullary area, should be eliminated. Periodic epidural procaine blocks may deserve diagnostic and therapeutic trial.

If the major degree of involvement of the pancreas, as revealed by roentgenologic study and surgical exploration, is localized either to the proximal or distal part of the pancreas, and if the technical hazards of partial pancreatectomy are not extreme, by virtue of the associated peripancreatitis, subtotal pancreatectomy may be employed satisfactorily. At the time of partial pancreatectomy, performed in the presence of calcareous deposits, the transected major duct should be explored for residual intraductal stones. If the distal portion of the gland is removed, the transected surface is closed with mattress sutures of silk. If the proximal part of the pancreas is resected, a pancreatojejunostomy should be performed. Although Waugh,[15] Whipple,[16] and others have employed total pancreatectomy for the relief of pain in pancreatolithiasis and calcinosis, we have not utilized it in this clinic. The mortality, immediate and delayed, of total pancreatectomy is not yet sufficiently low to justify its application to this benign disease except in very unusual circumstances, or until less hazardous surgical measures have proven ineffective.

It should be remarked, in this regard, that it is extremely difficult to evaluate the results of any particular methods of therapy in those patients who are addicted to alcohol or narcotics unless the relief of the pain is complete. Failure to make proper allowance for this factor of unreliability in the patient's description of his pain may lead to the application of extensive surgical procedures which are hazardous, out of all proportion to the degree of relief which can be expected. It is wise, therefore, to observe these patients for an appropriate time under strict hospital control in order that one may form some objective estimate of the severity of the pain before resorting to extremely hazardous surgical maneuvers in the treatment of this benign disease.

Ligation of the Duct of Wirsung. Martin and Canseco[9] reported the ligation of the duct of Wirsung, performed by Rienhoff[12] in the treatment of pancreatolithiasis. Several small stones were removed from the ducts, which were then presumably ligated by a series of sutures in the head of the pancreas. The patient was relieved of pain and remained symptom-free for ten months, at which time he was last examined. It is difficult in this particular case to evaluate the relative role of the mass ligatures and the removal of the stones from the duct, either of which might have been responsible for the relief of the pain. One may also object to this procedure on the premise that it will eliminate the external pancreatic secretions and impair digestion and absorption. We have

had no personal experience with this maneuver, but it is a provocative concept which deserves further evaluation.

Pancreatojejunostomy. Cattell[2] has suggested that obstruction of the duct of Wirsung in pancreatolithiasis may be responsible for the associated pain in pancreatolithiasis and has speculated about the possible benefit that might derive from the anastomosis of the duct of Wirsung to a defunctionalized loop of jejunum. This procedure would seem applicable to the uncommon situation where one could demonstrate that the opening of the pancreatic duct into the duodenum is occluded, and where the calcareous deposits are limited to the major ducts.

INOPERABLE CARCINOMA OF THE PANCREAS

Carcinoma of the pancreas, particularly when it has extended beyond the limits of resectability, is not a painless disease. Even in the early stages variable degrees of general abdominal discomfort and indigestion occur. As the pathologic process progresses and the duct of Wirsung becomes obstructed, frank pain in the epigastrium extending to the back is quite common. With the exclusion of the pancreatic ferments from the intestinal tract the patient suffers from diarrhea, gas and distention. Cattell has advocated the anastomosis of the duct of Wirsung to a defunctionalized loop of upper jejunum in order to relieve the pain and to improve the digestion. The procedure is not difficult to perform and the mortality is very low. The degree of palliation has been striking in some instances, in terms of relief of pain and improvement in nutrition.

Cordotomy. Occasionally the pain associated with inoperable or recurrent carcinoma of the pancreas is so extreme as to warrant the utilization of cordotomy, when less radical measures prove unsuccessful.

PANCREATIC CYSTS

Primary uncomplicated pancreatic cysts, and even pseudocysts secondary to pancreatic trauma or pancreatic necrosis, are essentially painless. They may be treated in this stage by simple drainage, marsupialization, excision or internal drainage. If they are neoplastic in origin, if they become infected or if they recur following surgical intervention, pain may be a prominent clinical feature and successful treatment may demand radical surgical maneuvers. We prefer, under such circumstances, to resect the recurrent cyst, along with the involved segment of the pancreas.

REPORT OF CASES

Proximal Pancreatoduodenectomy

CASE 1. A man, 42 years of age, was seen in the clinic on March 14, 1949, complaining of upper abdominal pain of three years' duration. The attacks had increased in frequency and severity. Cholecystectomy and choledochostomy had been performed elsewhere despite negative cholecystograms The attacks persisted and re-exploration was performed in December 1948. Pancreatic calculi were found and some of them were removed and the common duct was drained. The pain persisted, the patient lost 30 pounds in weight and had persistent diarrhea. The patient showed evidence of recent weight loss. Glucose tolerance was diminished. Serum amylase

values did not rise following the parenteral administration of secretin. Roentgenograms of the abdomen showed an area of calcification to the right of the transverse process of the second lumbar vertebra and smaller deposits in the midline at the same level.

At operation, on March 15, 1949, the head of the pancreas was enlarged and firm, with areas of fat necrosis scattered diffusely throughout the right upper quadrant. The body and tail of the pancreas were firm and edematous. A 5 cm. remnant of the gallbladder and cystic duct was present. Pancreatoduodenectomy was performed, excising the head and neck of the gland. The postoperative course was uneventful. The patient has been greatly relieved of his abdominal pain.

Distal Pancreatectomy

CASE 2. A woman, 32 years of age, was first seen at the clinic on September 30, 1940, with typical signs and symptoms of primary hyperthyroidism. Chest roentgenograms showed bilateral pulmonary tuberculosis. She was hospitalized and treated with Lugol's solution. Subtotal thyroidectomy was performed without incident. Postoperatively she was treated in another institution for tuberculosis by strict bed rest and artificial pneumothorax.

The patient returned to the clinic June 7, 1945, because of intermittent pain in the epigastrium which radiated to both right and left sides of the abdomen and into the back. The attacks were infrequent in the beginning, but appeared with increasing frequency as the illness progressed. Roentgenograms of the abdomen revealed a mottled area of increased density in the region of the pancreas. A diagnosis of pancreatolithiasis was made and the patient was placed on a bland diet and given antispasmodic drugs. The attacks persisted, and in July 1946, she had a severe episode of pain associated with massive hemorrhage from the rectum and stomach. She was readmitted to the hospital November 16, 1946, for study.

The patient weighed 98 pounds. Physical examination was negative except for the signs of active pulmonary tuberculosis. Eeophagoscopy revealed no varices. Liver function tests were negative.

At operation on December 4, 1946, the spleen was six times normal size and large varices were present in the gastric veins. The pancreas was enlarged and contained multiple areas of calcification in the body of the gland. In view of the diffuse involvement of the body and the tail of the gland, a distal pancreatectomy was performed. The spleen was removed. She had been free from pain when last seen at the clinic six months following the operation.

Marsupialization of Cyst—Subsequent Pancreatoduodenectomy

CASE 3. A man, 39 years of age, was examined in the clinic in May 1946 complaining of abdominal pain of six years' duration. The pain was intermittent and was prone to occur following excessive consumption of alcohol. The pain varied in intensity but was frequently severe. He had lost 28 pounds.

The patient was malnourished and nervous. A large firm tender mass was palpable in the epigastrium. Plain films of the abdomen showed a diffuse area of increased density in the epigastrium extending into the left upper quadrant. Roentgengrams taken immediately following the ingestion of barium showed the stomach to be displaced superiorly by an extrinsic mass.

At operation, July 10, 1946, a large cyst was found in the head of the pancreas. The tail of the pancreas was fibrotic and contained numerous calculi. In view of the marked inflammatory reaction present, the cyst was marsupialized. Postoperatively,

drainage was copious for four weeks. The patient was reasonably free of pain for several months, but returned to the clinic in November 1948 complaining of chronic, severe epigastric distress. Studies revealed a progression of the calcification in the pancreas. A firm mass was palpable in the region of the pancreatic head. The patient was reexplored and radical pancreatoduodenectomy performed. The distal portion of the pancreas was anastomosed to the upper jejunum. The segment of the pancreas which was removed showed areas of fibrosis, cystic degeneration and calcification. Glucose tolerance was slightly impaired but the patient did not require insulin. He has been relatively free of pain since the last operation.

CASE 4. A man, 39 years of age, came to the clinic on October 7, 1946, because of intermittent attacks of epigastric pain of eighteen months' duration. The episodes gradually progressed in severity and duration. He required regular quantities of demerol and morphine for relief. He used alcohol to excess. There was mild epigastric tenderness. The serum amylase measured 107 units. The urine contained 2.5 mg. of glucose per 100 cc. Cholecystograms showed nonvisualization of the gallbladder. Roentgenograms of the abdomen dmonstrated numerous calculi in the region of the pancreatic area. Despite careful dietary regulation and the administration of antispasmodic agents, the episodes of pain recurred.

At operation, the pancreas was enlarged in all dimensions. The gallbladder and common duct contained no stones and appeared normal. Because of the uniform involvement of the pancreas it was thought that a partial pancreatectomy would not relieve the pain. Consequently, a thoracolumbar sympathectomy and splanchnicectomy were done on the right side, approximately two weeks following his abdominal exploration. The pain was controlled for four months. Following an episode of intemperate drinking, the pain recurred at frequent intervals, particularly on the left side. The patient was readmitted to the hospital in June 1949 and a left thoracolumbar sympathectomy was performed. He has had occasional attacks of distress since the final operation, but has gained weight and has returned to work.

Pancreatojejunostomy for Inoperable Carcinoma of the Pancreas

CASE 5. A man, 59 years of age, was examined in the clinic on July 12, 1948, complaining of epigastric pain, jaundice and loss of weight of seven months' duration. He was deeply jaundiced, the liver edge was 6 cm. below the costal margin. A diagnosis of carcinoma of the pancreas was made. At operation, an inoperable carcinoma arising in the head of the pancreas was observed. The duct of Wirsung was dilated. A longitudinal incision was made in the duct of Wirsung and the duct anastomosed in continuity with a loop of upper jejunum. A cholecystjejunostomy was performed. The postoperative course was uneventful and the patient was discharged from the hospital July 31, 1948.

A letter from the patient's daughter in January 1949 related that the patient died December 21, 1948 He had no recurrence of the epigastric pain which he experienced prior to the palliative decompression of his pancreas and biliary tree.

SUMMARY

A variety of causes of pancreatic pain is discussed. Certain methods of controlling acute and chronic pancreatic pain are appraised

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drainage was copious for four weeks. The patient was reasonably free of pain for several months, but returned to the clinic in November 1948 complaining of chronic, severe epigastric distress. Studies revealed a progression of the calcification in the pancreas. A firm mass was palpable in the region of the pancreatic head. The patient was re-explored and radical pancreatoduodenectomy performed. The distal portion of the pancreas was anastomosed to the upper jejunum. The segment of the pancreas which was removed showed areas of fibrosis, cystic degeneration and calcification. Glucose tolerance was slightly impaired but the patient did not require insulin. He has been relatively free of pain since the last operation.

CASE 4. A man, 39 years of age, came to the clinic on October 7, 1946, because of intermittent attacks of epigastric pain of eighteen months' duration. The episodes gradually progressed in severity and duration. He required regular quantities of demerol and morphine for relief. He used alcohol to excess. There was mild epigastric tenderness. The serum amylase measured 107 units. The urine contained 2.5 mg. of glucose per 100 cc. Cholecystograms showed nonvisualization of the gallbladder. Roentgenograms of the abdomen dmonstrated numerous calculi in the region of the pancreatic area. Despite careful dietary regulation and the administration of antispasmodic agents, the episodes of pain recurred.

At operation, the pancreas was enlarged in all dimensions. The gallbladder and common duct contained no stones and appeared normal. Because of the uniform involvement of the pancreas it was thought that a partial pancreatectomy would not relieve the pain. Consequently, a thoracolumbar sympathectomy and splanchnicectomy were done on the right side, approximately two weeks following his abdominal exploration. The pain was controlled for four months. Following an episode of intemperate drinking, the pain recurred at frequent intervals, particularly on the left side. The patient was readmitted to the hospital in June 1949 and a left thoracolumbar sympathectomy was performed. He has had occasional attacks of distress since the final operation, but has gained weight and has returned to work.

Pancreatojejunostomy for Inoperable Carcinoma of the Pancreas

CASE 5. A man, 59 years of age, was examined in the clinic on July 12, 1948, complaining of epigastric pain, jaundice and loss of weight of seven months' duration. He was deeply jaundiced; the liver edge was 6 cm. below the costal margin. A diagnosis of carcinoma of the pancreas was made. At operation, an inoperable carcinoma arising in the head of the pancreas was observed. The duct of Wirsung was dilated. A longitudinal incision was made in the duct of Wirsung and the duct anastomosed in continuity with a loop of upper jejunum. A cholecystjejunostomy was performed. The postoperative course was uneventful and the patient was discharged from the hospital July 31, 1948

A letter from the patient's daughter in January 1949 related that the patient died December 21, 1948 He had no recurrence of the epigastric pain which he experienced prior to the palliative decompression of his pancreas and biliary tree.

SUMMARY

A variety of causes of pancreatic pain is discussed. Certain methods of controlling acute and chronic pancreatic pain are appraised.

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PARTIAL PANCREATECTOMY: EXCISION OF THE TAIL AND BODY OF THE PANCREAS

RICHARD B. CATTELL

Considerable progress has been made in recent years in the surgical treatment of diseases of the pancreas. With increased interest and study of this problem, more conditions have been successfully treated by partial or total removal of this gland. Unfortunately, there are serious obstacles to the establishment of correct diagnosis both before operation and at the time of abdominal exploration. With an increasing experience in the management of these lesions it is probable that means will be discovered which will permit more accurate diagnoses. It is only by keeping in mind the possibility of the presence of the lesions of the pancreas in obscure upper abdominal conditions that the presence of the pancreatic lesions may be suspected or proved. Unfortunately, there are few diagnostic aids, such as the roentgenographic visualization of organs adjacent to the pancreas, when distortion or displacement of these organs occurs. Determinations are made of the amylase or lipase concentration in the blood and incomplete digestion of carbohydrates and protein may be found by special studies of the stools. At times lesions of the pancreas attain sufficient size to produce localizing signs in this region. For the most part, however, it is necessary to make a presumptive diagnosis of a pancreatic lesion based on the history in the absence of other demonstrable findings.

There has been sufficient experience in the surgical treatment of pancreatic lesions to demonstrate that this organ is amenable to surgical attack. When the lesion involving the pancreas is sufficiently serious to justify a major procedure it must be appreciated that it carries considerable risk both as to morbidity and mortality. In the Surgical Clinics of North America for June 1948, I presented the technic employed in this clinic for removal of malignant lesions involving the lower end of the common bile duct, ampulla of Vater, duodenum and head of the pancreas. This procedure of radical pancreatoduodenal resection has been carried out for 63 malignant lesions and 5 benign lesions in this area, with mortality of approximately 13 per cent. We have encountered fewer lesions that are confined to the tail or body which are amenable to surgical removal. In the past three years, partial pancreatectomy with removal of the tail and body of the pancreas has been carried out a number of times without mortality. The technic of this operation will be presented.

INDICATIONS FOR OPERATION

1. Cysts of the Pancreas
2. Recurrent Relapsing Pancreatitis

Originally published in Surgical Clinics of North America, 29.779–785 (June) 1949.

3. Pancreatolithiasis
4. Pancreatic Fistulas
5. Islet Adenoma
6. Carcinoma of the Body of the Pancreas

The single cysts encountered in the body of the pancreas that do not communicate with the ducts can usually be excised without removal of portions of the pancreas. When they are of large size and associated with chronic inflammation, operation may be conducted in two stages with marsupialization and drainage of the cyst at the first stage, followed by removal of the tail and body in three months, during which time the cavity shrinks to a small size, permitting more accurate identification of the surrounding structures. Most of the single cysts that communicate with the ducts are best treated either in one or two stages by partial pancreatectomy. The multilocular cysts which usually follow recurrent inflammation of the gland may be treated in a similar manner, but all require resection of the body to accomplish complete relief of symptoms. We have not encountered multiple or multilocular cysts that appear to be of congenital type.

Increasing numbers of patients are being seen with chronic relapsing pancreatitis. If the process is chiefly confined to the body, partial pancreatectomy offers the best chance of relief of the disabling pain and digestive symptoms. This lesion is likely to be extensive and in some cases, after exploration, partial pancreatectomy has been deemed unwise and an attempt made to relieve the symptoms by left thoracolumbar sympathectomy.

Pancreatolithiasis is infrequently encountered. We have observed cases with the stones confined to the head, and 2 cases with pancreatolithiasis and diffuse calcinosis limited to the body and tail. The severe symptoms present in these cases justify partial pancreatectomy when technically feasible. It has been carried out in 2 patients.

Pancreatic fistula may be the result of trauma or penetrating wounds or may follow acute pancreatitis when drainage has been instituted. Pancreatic fistula, however, most frequently occurs as a result of drainage of cysts of the pancreas. At times, these fistulas may be transplanted into the jejunum or stomach. Excision of the fistula with closure of the communications to the pancreatic ducts is rarely successful. Partial pancreatectomy may be the most effective means of curing this condition. Failure to discover hyperfunctioning pancreatic adenomas of the islet cells may necessitate partial pancreatectomy, as suggested by Waugh, when the adenoma cannot be discovered. In the few patients treated at the clinic the adenoma has been found and removed locally but in 1 case in which the adenoma showed malignant degeneration, partial pancreatectomy was carried out by Marshall.

We have had no experience with partial pancreatectomy for carcinoma of the body of the pancreas A successful case was reported by Gordon-Taylor in 1934; the patient was living at that time, seven years after partial pancreatectomy. Unfortunately, most of the malignant lesions of the body of the pancreas already have extended beyond the gland, making resection impossible.

ANATOMY

The most satisfactory approach for exposure of the body and tail of the pancreas is through the gastrocolic omentum on the left side. The tail of the pancreas is usually in close relationship to the lower portion of the hilum of the spleen and injury to the latter structure may be unavoidable, particularly if chronic inflammation of the pancreas is present. The upper portion of the transverse mesocolon may likewise be densely adherent to the inferior border of the pancreas, making a line of dissection difficult to obtain. The stomach is usually adherent to the anterior surface of the pancreas, but can usually be disengaged without difficulty.

The protection of the vascular structures in the region of the pancreas is the most difficult technical part of the operation. These structures are by no means constant in their course and relationship and must be individually identified as the procedure is carried out. The splenic artery passes along the superior aspect of the body, giving off branches to both the body and tail. There are large longitudinal arteries from the gastroduodenal artery that pass into the pancreas on its superior aspect. Similarly, the inferior pancreatoduodenal artery gives large branches to the body on the inferior surface. Both the middle colic arteries and the inferior mesenteric artery must be carefully identified and displaced downward to avoid injury.

The large venous channels in this area are even more difficult to identify and protect than the arteries. The splenic vein lies on the superior aspect of the body and, as it passes to the left, comes to rest behind the body and tail. When inflammation is present it may appear to be an integral part of the pancreas. The junction of the splenic and superior mesenteric veins forms the portal vein and must be identified previous to division of the neck of the pancreas.

In partial pancreatectomy only the duct of Wirsung is encountered. The accessory duct rarely passes beyond the neck of the pancreas If some degree of obstruction to the duct is present it can usually be identified by palpation on the anterior surface or by aspiration.

PHYSIOLOGY

The greater concentration of the islet tissue is found in the tail of the pancreas. There is sufficient islet tissue in the head to maintain normal carbohydrate metabolism after removal of the body and tail in most cases. Diabetes mellitus has been present preoperatively in a number of our cases of partial pancreatectomy but has not been made more severe by the procedure. In no patients following partial pancreatectomy has diabetes mellitus resulted. Similarly, there is sufficient tissue for the production of adequate amounts of pancreatic ferment from the head of the pancreas when the body has been removed. Some steatorrhea has been observed following partial pancreatectomy, however, as evidenced by incomplete fat digestion as well as by abnormal digestive symptoms.

TECHNIC OF PARTIAL PANCREATECTOMY

The abdomen is opened and explored through a left rectus incision, usually paramedian in position, deflecting the rectus muscle outward to the left. The anterior two layers of the gastrocolic omentum are divided, preserving the gastro-

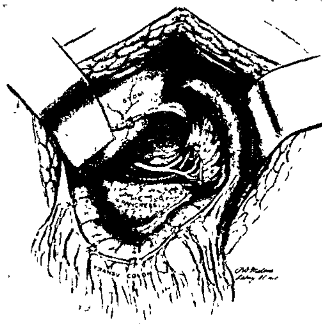


Fig. 297. Exposure of the body of the pancreas by division of the gastrocolic omentum. Wide exposure of this region is readily obtained.

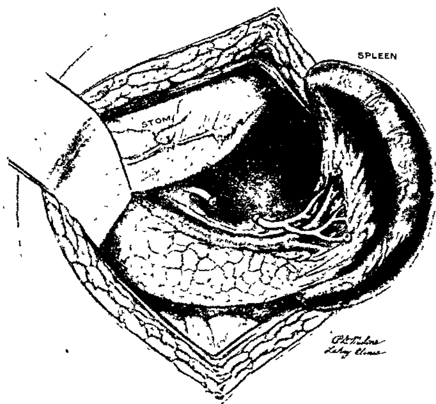


Fig 298. The splenic artery has been ligated and divided, as well as the vasa brevia. The spleen has been delivered from the wound and the tail of the pancreas is elevated.

epiploic arteries along the greater curvature of the stomach. The gastrohepatic omentum is opened widely (Fig. 297) extending from the right margin of the lesser sac to the spleen. The splenocolic ligament is divided, displacing the splenic flexure of the colon downward. Elevation of the stomach and depression of the posterior layers of the transverse mesocolon permit wide exposure and access to the body and tail of the pancreas (Fig. 297).

Most of the lesions involving the body and tail for which partial pancreatectomy is necessary lead to such gross changes in the pancreas and adjacent structures that the limits of the pancreas are hard to determine. For this reason, removal of the spleen, leaving it attached to the pancreas, is necessary. The splenic artery is first identified as it comes down from the celiac axis (Fig. 297). It is ligated and divided at the point where it passes to the left at a considerable distance from the spleen (Fig. 298). After division of the vasa brevia vessels to the upper portion of the spleen, the latter is delivered from the wound with elevation of the tail of the pancreas (Fig. 298).

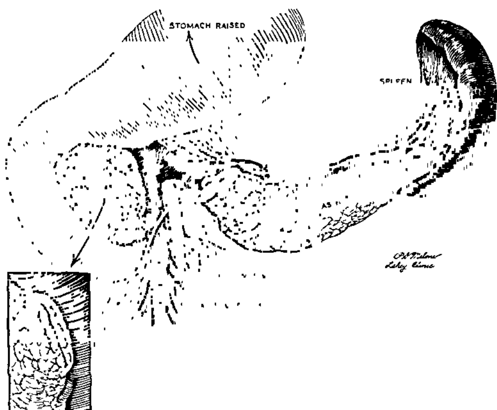


Fig. 299. Diagrammatic representation of the major structures encountered at the junction of the body and head of the pancreas. The splenic vein has been ligated (as have the branches from the gastroduodenal and superior mesenteric arteries). The neck of the pancreas has been divided showing the duct of Wirsung
Inset, Closure of the cut end of the pancreas.

Dissection is then carried out from in back, elevating the spleen and tail of the pancreas from the kidney and identifying the structures of the hilum of the kidney. Great care must be directed to protect the inferior mesenteric artery and vein, which are in contact with the inferior margin of the body of the pancreas, separated only by the one posterior layer of the peritoneum of the transverse

mesocolon. With further elevation of the body of the pancreas, the splenic vein is isolated and separated from the superior aspect of the pancreas. Displacement of this structure backward permits its accurate ligation and division. The proximal side of the splenic vein is then followed to its junction with the superior mesenteric vein. At times this dissection must be discontinued because of technical difficulties, and the neck of the pancreas is elevated after identification of the superior mesenteric vein and portal vein. The longitudinal superior pancreatic arteries, both anterior and posterior, as they leave the gastroduodenal artery are now secured and ligated. Following this, the short arterial branches of the superior mesenteric artery at the inferior border of the pancreas are dealt with. If the neck of the pancreas has not already been divided, it is divided at this time, with removal of the operative specimen (Fig. 299). As the neck of the pancreas is sectioned, the duct of Wirsung is identified and carefully closed by nonabsorbable suture ligatures. The neck of the pancreas is then carefully closed by interrupted nonabsorbable sutures, as shown in Figure 299, inset. This results in good hemostasis of the cut end of the pancreas, as well as effective closure of the tiny duct radicals.

Gelfoam is quite useful in the control of ooze from the bed of the pancreas. A small incision is then made through the gastrohepatic omentum for the introduction of a cigarette gauze drain to the bed of the pancreas. The gastrocolic omentum is then closed.

SUMMARY

An increasing number of lesions of the pancreas are being encountered which involve the body and tail.

Indications for partial pancreatectomy with excision of the tail and body of the pancreas are: cysts, recurrent cysts, chronic relapsing pancreatitis, pancreatolithiasis, pancreatic fistulas, islet adenoma and carcinoma. Inflammatory lesions are the most common.

A technic for partial pancreatectomy is presented.

A TECHNIC FOR PANCREATODUODENAL RESECTION

RICHARD B. CATTELL

Increasing numbers of patients have been submitted to resection of the head of the pancreas for carcinoma in this general area. This includes resection for carcinoma of the ampulla, carcinoma of the head of the pancreas and carcinoma of the lower end of the common bile duct as well as an occasional carcinoma arising in the mucosa of the second portion of the duodenum. Of these malignancies, carcinoma of the head of the pancreas is somewhat more frequent. During an early stage, carcinoma of the head of the pancreas can usually be demonstrated to have arisen from the pancreatic ducts. In the more advanced cases, particularly in autopsy findings, with the spread of the lesion the point of origin cannot be determined. Malignancies in the pancreatoduodenal area comprise between 1 and 2 per cent of all malignancies, so that the total experience in the surgical management of these lesions has been somewhat limited when compared to carcinoma of the stomach or carcinoma of the large intestine. A large number of reports is now available in the literature for review which demonstrate clearly that the operation is technically feasible. A further long period of follow-up will be necessary to judge the efficacy of these procedures.

A number of technics for pancreatoduodenal resection, both in one and in two stages, has been described since the original report of Whipple, Parsons and Mullins[20] in 1935, which was a two-stage operative procedure. Trimble, Parson and Sherman described a one-stage procedure in 1941, with a successful outcome. In addition, reports by Hunt and Budd, Brunschwig, Hunt, Harvey and Oughterson, Orr,[12,13] additional communications by Whipple,[17-19] and the author[2-8] have described different technics and results. Pearse more recently called attention to the need of standardization of these procedures.

The essential feature of a suitable operative procedure for pancreatoduodenal resection emphasized originally by Whipple and his associates[18] is the plan for a block resection of the head of the pancreas, lower end of the common duct, pylorus of the stomach and the duodenum. In the performance of the operation, the biliary tract, gastrointestinal tract and pancreas are interrupted. Restoration of the biliary tract is best accomplished by the anastomosis of the common duct or common hepatic duct to some portion of the gastrointestinal tract, although in the two-stage operation it can be accomplished satisfactorily by anastomosis of the gallbladder. The gastrointestinal tract can be restored by end-to-end or end-to-side gastrojejunostomy.

The author early called attention to the importance of the anastomosis of the main pancreatic duct in carrying out these resections. Although in the earlier experience of Whipple and in the case reported by Trimble the pancreatic ducts

Revision of article originally published in Surgical Clinics of North America, 28:761–775 (June) 1948

were closed, demonstrating that this is consistent with recovery, I pointed out that there were fewer complications postoperatively when the duct was anastomosed. This reduces the incidence of pancreatic fistula, peritoneal infection and postoperative hemorrhage. Furthermore, the return of the external secretion of the pancreas to the intestine is an important aid in proper utilization of protein and fats. It is generally agreed today that the anastomosis of the pancreatic duct should be done routinely during pancreatoduodenal resection.

If the pancreatic duct is not dilated its anastomosis may be technically difficult. This can be overcome by the technic which I described[2,5] in which a closed anastomosis by means of a pressure necrosing suture joins the duct to the jejunum. If the duct is dilated, it can be anastomosed without difficulty over a tube in a similar fashion to the choledochojejunostomy.

In our experience, between 25 and 30 per cent of the malignant lesions in the periampullar region can be resected. Carcinoma arising in the ampulla is the most favorable, while carcinoma of the head of the pancreas, of the duodenum and of the common bile duct are more likely to show spread beyond the limits of possible resection.

CONTRAINDICATIONS TO RESECTION

As one's experience increases with the management of these lesions it becomes apparent that resection of advanced malignant disease in this area is not worth while, both because of the technical difficulties involved and also because of the short duration of life under these circumstances. We have found that if the line of resection passes through an area involved by malignancy, even though a satisfactory postoperative recovery follows, diffuse abdominal metastases will be found within a few weeks or months. For this reason and also because of the very extensive operative procedure necessary, resection should be confined to the favorable lesions. We consider four findings a contraindication to operation: (1) distant metastases, (2) local spread with direct invasion beyond a possible limit of resection; (3) involvement of the superior mesenteric vessels, and (4) involvement of the portal vein.

During the abdominal exploration one should carefully search for evidence of metastases. In some cases it will be necessary to biopsy the liver and examine a frozen section since in some patients with negative palpation of the liver and negative inspection, microscopic metastases may be demonstrated on frozen section. Biopsy of nodes along the hepatic artery, or of those at the superior aspect of the pancreas and below the common duct may be important. Direct invasion or local spread may be demonstrated in the region of the gastroduodenal artery or posteriorly in the region of the inferior vena cava. Unless the area can be elevated beyond the malignancy, resection should not be done. The involvement of the superior mesenteric vessels can be determined by division of the gastrocolic omentum and incision of the peritoneum on the inferior border of the pancreas. Similarly, the portal vein can be identified by division of the gastroduodenal artery and displacement of the common duct downward, permitting digital examination of the posterior surface of the head of the pancreas, displacing the portal vein backward. If the portal vein is involved, resection is contraindicated.

PALLIATIVE OPERATIVE PROCEDURES

Relief of the obstructive jaundice by anastomosis of the biliary tract to the gastrointestinal tract has long been considered to be the sole palliation possible. The immediate relief of the obstructive jaundice by an operation such as cholecystojejunostomy is very striking and a welcome relief to the patient of the accompanying pruritus. In most cases, however, this relief is quite temporary, as demonstrated by the follow-up results. In a consecutive series of 56 patients who had cholecystojejunostomy usually with jejunojejunostomy, performed in this clinic, 75 per cent were found to be dead nine months after the onset of their obstructive jaundice, or an average of six months after the biliary tract anastomosis. The relief of the obstructive jaundice does not greatly improve the nutritional state of the patient if complete block of the pancreatic ducts persists. For this reason, when the duct of Wirsung is found to be dilated we recommended a side-to-side anastomosis of the duct of Wirsung to the jejunum just proximal to the cholecystojejunostomy. The technic of this was described in the *Surgical Clinics of North America* in June 1947.[6] We have now performed this anastomosis in 22 patients, with no immediate hospital mortality.

One can consider four palliative procedures for inoperable carcinoma of the head of the pancreas. (1) cholecystojejunostomy with enteroenterostomy; (2) pancreatojejunostomy; (3) ligation of the gastroduodenal artery and inferior pancreatoduodenal artery, and (4) gastrojejunostomy.

Cholecystojejunostomy need not be discussed further. In our experience it is better to anastomose the gallbladder to the jejunum rather than to the stomach or to the duodenum. Large amounts of bile are not tolerated well in the stomach. Anastomosis of the gallbladder to the duodenum should not be done because of its proximity to the malignant lesion. When the gallbladder is anastomosed to an antecolic loop of jejunum it places the anastomosis at the greatest distance from the malignancy and is less likely to become involved early by extension of the malignant disease. If the gallbladder has been removed previously, a side-to-side anastomosis of the common duct or common hepatic duct to the jejunum is performed.

A side-to-side anastomosis of the duct of Wirsung to the jejunum is not technically difficult. A point is selected on the jejunum about 3 or 4 inches (7.5 or 10 cm.) proximal to the cholecystojejunostomy and a direct anastomosis done over a T-tube, as previously described.[6]

An enteroenterostomy is done in all cases of cholecystojejunostomy alone or when cholecystojejunostomy and pancreatojejunostomy have been done.

It is impossible to prove what effect reduction of the blood supply to an inoperable tumor accomplishes. The gastroduodenal artery is the source of the major arterial supply to the head of the pancreas. In most cases identification of the hepatic artery and the gastroduodenal artery can be done and ligation of the latter structure with or without division carried out. We have done this a number of times in inoperable cases and in a few have combined it with ligation in continuity of the inferior pancreatoduodenal artery. From a theoretical point of view it may possess some value.

In a few patients with inoperable carcinoma in this area, the duodenum

already shows evidence of obstruction. Under these circumstances a gastrojejunostomy is performed. This can be done in conjunction with the other three procedures and it makes an enteroenterostomy unnecessary since the stomach can be anastomosed to the efferent loop of jejunum beyond the pancreatic and gallbladder anastomoses.

CONFIRMATION OF THE DIAGNOSIS

A discussion of the diagnosis of cancer of the head of the pancreas is not pertinent to this paper. With few exceptions, a gradually increasing painless obstructive jaundice is present. The liver is enlarged and the gallbladder will usually be palpable. On exploration, the gallbladder and common bile duct will be found to be markedly dilated. In over half the cases, the duct of Wirsung is dilated and can be readily palpated through the gastrohepatic omentum. This can be felt in the mid portion of the body of the pancreas as a longitudinal cystic structure at the junction of the middle and upper thirds of the pancreatic body. If no tumor can be palpated at the ampulla or in the head of the pancreas, the finding of dilatation of the biliary tract or dilatation of the duct of Wirsung may be the only means of establishing the diagnosis. In the very early lesions originating in the head of the pancreas in one of the main pancreatic ducts only dilatation of the duct of Wirsung may be found. Under most circumstances the diagnosis of carcinoma in this location cannot be established by biopsy. Biopsy of the head of the pancreas is rarely of help in establishing the diagnosis as a frozen section report will usually show only chronic pancreatitis. Biopsy of ampullar lesions can be accomplished by the transduodenal approach, but is not necessary as they can be readily felt through the duodenal wall. The biopsy of any regional nodes that show enlargement may be of help. Small tumors in the head of the pancreas may be felt after elevation of the duodenum and head of the pancreas. With few exceptions in our experience, it was necessary to proceed with resection without positive histologic diagnosis, but *it should be emphasized that resection is not proceeded with unless dilatation of either the pancreatic ducts or biliary tract can be demonstrated.*

DETERMINATION OF OPERABILITY

In the deeply jaundiced patient, particularly those who have a history of several weeks of obstructive jaundice, exploration should be limited to palpation and possibly liver biopsy. An antecolic cholecystojejunostomy should be performed as the sole procedure since any extensive dissection of the operative field causes adhesions and makes the second stage resection more difficult. If this opinion is accepted it may be found in some cases that at a second stage exploration in two or three weeks the lesion may be found to be inoperable, resulting in two operations without resection. Under these circumstances it may be feasible to do anastomosis of the duct of Wirsung as well as the enteroenterostomy at this time. If the condition of the patient warrants a one-stage pancreatoduodenal resection, one proceeds to establish the diagnosis as outlined above and also to determine the operability. Fortunately, one can determine operability without being committed to resection and before interruption of

either the gastrointestinal, biliary or pancreatic tracts. Thus, division of the gastrocolic omentum on the right side with demonstration of the superior mesenteric vessels and inferior border of the pancreas, division of the gastrohepatic omentum with ligation and division of the right gastric and gastroduodenal arteries permit exposure of the portal vein but do not make resection mandatory. With division of the peritoneum on the right side of the duodenum and elevation of the pancreatic head, posterior invasion or fixation can likewise be determined. At this stage in the operation one can at least demonstrate whether the resection is technically feasible, irrespective of the size of the tumor.

ONE-STAGE VERSUS TWO-STAGE OPERATION

There is an increasing trend for the selection of a one-stage operation for pancreatoduodenal resection. Whipple,[18,19] Trimble, Brunschwig, Waugh and others favor it. Without question, it is an easier operation technically; furthermore, the first-stage operation does not reduce the magnitude of the second-stage procedure. Its sole object is to accomplish relief of the obstructive jaundice, with the resultant improvement in liver function. Whipple emphasized that with a careful preoperative preparation, blood replacement and the use of synthetic vitamin K, a two-stage operation is not necessary. It is my opinion that a two-stage operation should be done in any patient who has a severe obstructive jaundice, particularly if it has been present for several weeks. Unfortunately, it is not possible to determine liver function accurately by the use of liver function tests in the presence of obstructive jaundice. If there is marked enlargement of the liver which is an accompaniment of obstructive jaundice, the patient is a poor candidate for one-stage resection. Cholecystojejunostomy can easily be performed with only a short period of preoperative preparation and can accomplish much more so far as liver function goes than can be accomplished by a long period of medical preparation. Fortunately, a first-stage procedure can be done which does not add materially to the technical difficulties of the second stage. This is not true of the early two-stage procedures which have been utilized. If a site is selected on the jejunum for the cholecystojejunostomy 15 to 18 inches (37.5 to 45 cm.) from the ligament of Treitz and this loop brought up in an antecolic position, one can displace it easily downward at the second-stage procedure without adding to the technical difficulties. In our earlier experience, in two-thirds of the patients who were submitted to resection the operation was done in two stages, in several, the first stage was done elsewhere. Since 1948, the number of one-stage resections has greatly increased, but an occasional two-stage resection is still done.

TECHNIC OF PANCREATODUODENAL RESECTION

Steps of the Procedure. The steps of the procedure will be listed in the order in which they are carried out and then later described. This order of operation is chosen because it permits one to establish the diagnosis and determine operability without committing the surgeon to the radical procedure. It enables one to establish the contraindications to operation and also permits the four possible procedures, including pancreatojejunostomy in the inoperable cases.

The steps are:

1. Exploration
2. Biopsy of lymph nodes and liver
3. Elevation of the duodenum and head of the pancreas
4. Division of the right half of the gastrocolic omentum
5. Freeing of the hepatic flexure and right half of the transverse colon
6. Exposure of the superior mesenteric vessels at the inferior border of the pancreas
7. Division of the gastrohepatic omentum
8. Ligation and division of the right gastric artery, anterior duodenal artery and gastroduodenal artery
9. Exposure of the portal vein and superior border of the body of the pancreas
10. Division of the common duct (closure of the common duct)
11. Division of the stomach in the prepyloric area
12. Division of the body of the pancreas (closure of the pancreas except the duct)
13. Division of the jejunum (freeing of the proximal jejunal mesentery)
14. Delivery of proximal jejunum and fourth portion of the duodenum to the right of the superior mesenteric vessels
15. Freeing of the uncinate process and division of the branches of the superior mesenteric artery and vein

This permits removal *en bloc* of the resected specimen.

Steps in the Reconstruction

16. Pancreatojejunostomy (anastomosis of the duct of Wirsung to the jejunum)
17. Choledochojejunostomy (end-to-side)
18. Jejunojejunostomy
19. Gastrojejunostomy
20. Insertion of cigarette drain and wound closure

The technic of the one-stage pancreatoduodenal resection as performed in this clinic will be described in detail, since this is the type of operation which has been employed routinely in our cases. In view of the fact that a two-stage operation is occasionally indicated when long-standing biliary obstruction has been present, we wish to point out that the first stage now consists of an antecolic long loop cholecystojejunostomy. The enteroenterostomy is not done at the first stage because it is too difficult to judge the amount of proximal jejunum which will be resected at the second stage. If the lesion is found inoperable at the second stage, the enteroenterostomy would then be done. The combination of cholecystojejunostomy and jejunojejunostomy is the palliative procedure we employ when palliation only can be offered. The first-stage procedure is shown in Figure 300. A wide anastomosis, utilizing the full width of the gallbladder, is essential. At the second stage this anastomosis is readily dispaced downward out

of the way of the procedure of pancreatoduodenectomy. The common duct can be implanted into the jejunum beside the cholecystojejunostomy if that is considered advisable, or if it does not encroach upon the cystic duct, the common duct can be closed. This cannot effectively be done by ligation; the duct must be carefully inverted just as one would a duodenal stump after gastrectomy. Rarely, in a two-stage procedure it is necessary to remove so much of the common duct that the cystic duct must be sacrificed and under those circumstances cholecystectomy is done and the usual hepaticojejunostomy performed for restoration of the biliary tract.



Fig. 300. First-stage cholecystojejunostomy. A long loop of jejunum is brought up in an antecolic position and anastomosed to the full width of the gallbladder.

The operation of one-stage pancreatoduodenal resection is carried out preferably through a long, right-sided incision, splitting the fibers of the rectus muscle. The steps necessary for confirmation of the diagnosis and determination of operability, as previously described, are then carried out. When resection is decided upon, the peritoneum is incised on the right side of the duodenum, with elevation of the duodenum and head of the pancreas and retraction of these structures to the left. The peritoneal attachments of the hepatic flexure and right half of the transverse colon are then severed and this portion of the large intestine displaced downward. With division of the anterior two layers of the gastrocolic omentum, the entire anterior aspect of the head of the pancreas is exposed as are the middle colic vessels. The peritoneum is then incised at the inferior border of the body of the pancreas, exposing the superior mesenteric vein. This permits further mobilization of the head of the pancreas and duodenum. Three structures are then identified on the posterior wall of the parietes; they are, from right to left, the ovarian or spermatic vein, the inferior vena cava and the aorta.

The lower half of the gastrohepatic omentum is then incised, identifying

ligating and dividing the right gastric artery and coronary vein. The anterior superior duodenal vessels are similarly isolated and divided, following which the anterior aspect of the lower common duct is exposed. At this time the hepatic artery should be identified throughout its course in the gastrohepatic omentum, following which the gastroduodenal artery is isolated, ligated and divided. It will be found to have a very short trunk before it divides, usually into four branches. This allows about 1 cm. of the artery to be dissected free.

The common duct is then freed up and the site of entry of the cystic duct exposed. The common duct is displaced downward and freed up and the hepatic

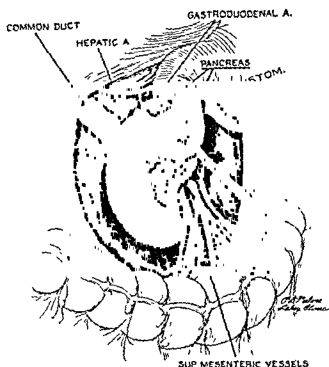


Fig 301. The peritoneum, on the right side of the duodenum, has been incised, permitting mobilization of the head of the pancreas. The gastrocolic omentum has been divided displacing the hepatic flexure and right half of the transverse colon downward, exposing the superior mesenteric artery and vein. The gastrohepatic omentum has been incised, exposing the hepatic and gastroduodenal arteries.

artery displaced upward and the anterior surface of the portal vein visualized. A finger can then be passed under the head of the pancreas on top of the portal vein which has no branches on its anterior aspect as far as its division into the splenic and the superior mesenteric veins. This finger can be made to emerge below the body of the pancreas to the left of the superior mesenteric vein. This exposure permits a further decision relative to operability of the lesion, since one cannot determine previously whether the portal vein or superior mesenteric vein is invaded by the tumor.

The common duct can then be divided between clamps at the proper point, which will vary greatly, depending upon the site of the malignancy.

The pyloric end of the stomach is then freed of its vascular supply, and clamps are placed across it 5 to 7 cm. proximal to the pylorus. With the previous severance of the gastrocolic and gastrohepatic omentums, this permits wide

mobility of the distal half of the stomach and the clamp on the distal end of the stomach can then be placed within the left abdomen so that it no longer obscures the field.

The body of the pancreas is lifted up on the finger and a point selected for transection of the body of the pancreas. The main arterial blood supply of the pancreatic body runs along the superior and inferior aspects as longitudinal pancreatic arteries. Suture ligatures are placed on both superior and inferior aspects of the pancreas, utilizing nonabsorbable suture material and including about 1 cm. of the pancreas. These are used in the distal portion of the pancreas

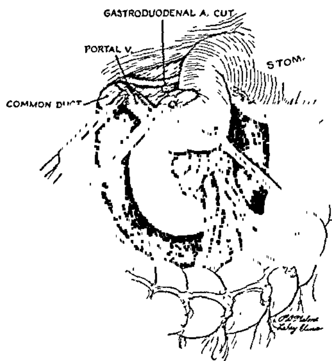


Fig. 302. The gastroduodenal artery has been ligated and divided after careful identification of the hepatic artery. The common duct has been freed up and divided between clamps, exposing the anterior wall of the portal vein and the gastrohepatic ligament

near the line of resection. The pancreas is then divided, controlling bleeding from the proximal side with Allis clamps. The duct of Wirsung is identified and dissected free before the pancreas is completely divided, and is left to project from the cut surface. With complete division of the pancreatic body the portal vein is exposed at the juncture of the superior mesenteric and splenic veins. The distal pancreatic body is then closed with interrupted mattress sutures of silk, leaving the duct of Wirsung open. If the duct is dilated, a catheter of appropriate size is placed in it. If the duct is small, as it is in certain ampullar lesions, it is ligated with fine, plain catgut, following which the duct is transfixed behind the tie with braided silk passing halfway through the duct. The remaining portion of the pancreas can then be displaced to the left of the operative field.

The transverse colon is raised and a point selected for division of the jejunum 10 to 15 cm. distal to the ligament of Treitz. The ligament of Treitz is completely severed, freeing up the proximal jejunum and fourth portion of the

duodenum. The mesentery of the proximal jejunum is divided and the vessels ligated. The jejunum is then transected between clamps and the proximal end closed, leaving the sutures long for traction.

The division of the ligament of Treitz, freeing the proximal jejunum and fourth portion of the duodenum beneath the superior mesenteric vessels, makes a free communication between this area and the dissection previously carried

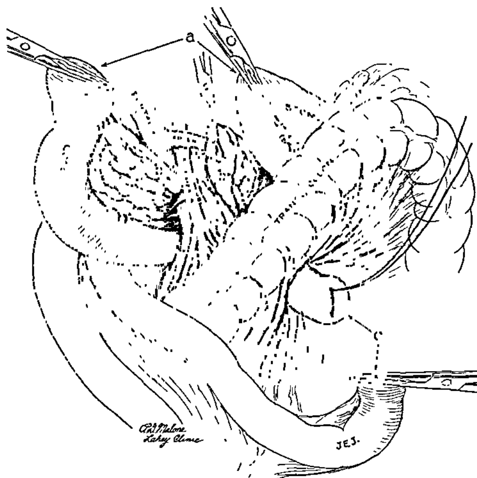


Fig. 303. The prepyloric area of the stomach has been divided between clamps. The body of the pancreas has been severed, exposing the junction of the portal, splenic and superior mesenteric veins The jejunum has been divided with closure of the proximal end preparatory to bringing it through to the right beneath the superior mesenteric vessels.

out on the right side of the abdomen. The proximal jejunum and the fourth portion of the duodenum are then drawn through to the right beneath the superior mesenteric vessels.

By elevation of the duodenum and the head of the pancreas, the uncinate process of the pancreas can be freed up posteriorly. This is the most difficult part of the operative procedure to accomplish effectively. This part of the dissection is aided by elevation of the pyloric end of the stomach, head of the pancreas, as well as the duodenum, permitting identification and division of the short branches of the superior mesenteric vein and superior mesenteric artery that go to the head of the pancreas, the uncinate process and the third and fourth portions of the duodenum. This completes all of the attachments

of the specimen to be resected *en bloc*. Gelfoam is very useful in the control of the capillary ooze in this retroperitoneal area.

The remainder of the operation consists of the steps necessary for reconstruction of the gastrointestinal, pancreatic and biliary tracts. A point is selected on the afferent loop of jejunum for the anastomosis of the pancreatic duct. If the duct is small, a pressure necrosing suture technic is used, as previously presented. Usually the duct of Wirsung will be large enough to permit careful suture over a rubber tube with an accurate mucosa-to-mucosa approximation. The amesenteric surface of the jejunum at the point selected is incised through

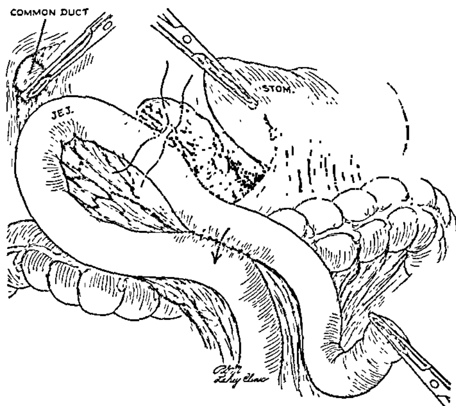


Fig. 304. Pancreatojejunostomy is illustrated. The cut end of the pancreatic body has been closed by mattress sutures, the amesenteric surface of the jejunum at the site selected for the anastomosis has been incised leaving the mucosa intact. Mucosa-to-mucosa suture of the duct of Wirsung to the jejunal mucosa is illustrated. The anastomosis is completed by buttressing the end of the pancreas to the jejunum.

the seromuscular coats for the same distance as the width of the cut, closed end of the pancreas. The jejunum is sutured to the pancreas with interrupted silk sutures, passing through the area previously closed by the mattress sutures of the pancreas to prevent the sutures from pulling out. When the posterior suture line has been completed, the mucosa of the jejunum is opened and two interrupted sutures of catgut are taken between the mucosa of the duct and the mucosa of the jejunum. A rubber tube is then inserted and anchored with a silk suture. Two interrupted sutures are taken in the mucosa anteriorly and the anastomosis is completed by interrupted silk sutures through the anterior wall of the jejunum and pancreas. We consider this part of the technic quite important in which the closed end of the pancreas is merely buttressed against the intact mucosal surface except for the actual ductal anastomosis.

Reconstruction of the biliary tract is accomplished by end-to-side hepaticojejunostomy, approximately 7 cm. distal to the pancreatojejunostomy. A two-layer anastomosis is accomplished over a large rubber tube. If the cystic duct has been encroached upon, cholecystectomy will be necessary.

Diversion of the pancreatic and biliary tract anastomoses is accomplished by side-to-side jejunojejunostomy performed at a comfortable distance from the two previous anastomoses. Gastrointestinal continuity is accomplished by end-to-end gastrojejunostomy.

It will be noted that all of these anastomoses are done in an antecolic position. In view of the high recurrence rate following these operations, by placing



Fig 305. The completed anastomoses following pancreatoduodenal resection. The biliary tract anastomosis, end-to-side, is shown. The procedure is completed by enteroenterostomy. All of the anastomoses are in an *antecolic* position. The pancreatic and biliary anastomoses are shown in the defunctionalized loop.

the anastomoses in the antecolic position they are less likely to be involved at an early stage by recurrent carcinoma. A cigarette drain is placed down to the retroperitoneal region at the site of the resected uncinate process and brought out between the biliary and pancreatic anastomoses through the upper portion of the wound.

Up to January 1, 1951, 90 pancreatoduodenal resections have been performed at the Lahey Clinic. Eleven of these were done for benign disease and 79 for carcinoma of the head of the pancreas, carcinoma of the ampulla, carcinoma of the duodenum and carcinoma of the common duct. In the earlier experience with 38 cases of pancreatoduodenal resection for carcinoma, there were 7 deaths, a mortality of 18.5 per cent. Since that time, 41 resections have been done with 3 deaths, a mortality of 7.3 per cent.

The anastomosis of the pancreatic duct in all cases is an important part of a

successful operative procedure. It has been performed, with one exception, in all of our pancreatoduodenal resections. All of these anastomoses of the duct were done as end-to-side either by the pressure necrosing suture technic or by open anastomosis. In our recent experience, an open type of anastomosis has been used almost exclusively. In our total experience with 90 pancreatoduodenal resections, we know of only one failure of a pancreatic anastomosis, and in this one fatal case, separation of the pancreas from the jejunum occurred. He had an unfavorable lesion with diffuse local lymph node metastases and at postmortem examination the proximal loop of the jejunum had become distended, causing tension on the suture line. In no instance has a biliary tract anastomosis failed in resected cases. In 2 patients obstructive symptoms developed because of a narrow gastrojejunostomy; both patients had a subsequent Heineke-Mikulicz type of plastic operation on this anastomosis, with uneventful recovery.

From this experience, we believe that from a technical point of view it has been demonstrated that pancreatoduodenal resection can be carried out with a reasonable operative mortality and with satisfactory restoration of function of the gastrointestinal, pancreatic and biliary tracts. Unquestionably, the high mortality in our earlier cases was related to poor selection of patients for the procedure. Many of the patients in this group had extensive carcinoma of the head of the pancreas who would not now be submitted to pancreatoduodenal resection.

RESULTS

A follow-up study on the patients having pancreatoduodenal resection for carcinoma has permitted a valuable appraisal of the procedure.[7,8] In this group of 79 patients, 42 had carcinoma of the head of the pancreas, 26 had carcinoma of the ampulla, 7 had carcinoma of the duodenum and 4 had carcinoma of the common duct. There were 10 postoperative deaths, giving an over-all operative mortality of 12.6 per cent. Two of the deaths occurred with carcinoma of the ampulla, 6 with carcinoma of the head and 2 with carcinoma of the duodenum. All patients have been traced.

Patients with carcinoma of the ampulla are by far the most favorable. There were 26 patients with two postoperative deaths, leaving 24 patients for analysis. Fifteen of the 24 patients lived over two years, but 7 subsequently died of recurrence. There are 8 patients living two years or more without recurrence. Six of 24 patients lived over five years but of these, 3 subsequently died of recurrence. Three patients having pancreatoduodenal resection for carcinoma of the ampulla are living over eight years.

There were 42 patients operated on for carcinoma of the head of the pancreas, with 6 postoperative deaths and 36 patients surviving operation; all have been traced Three of the 36 are now living, one over five years and 2 less than one year. 33 are known to be dead. Of all cases in this group, 2 patients lived five years or more, but one patient succumbed from recurrence. Ten patients of this group lived over a year, and 23 lived less than one year.

No patient having resection for carcinoma of the duodenum lived over five years. These are considered to be a very unfavorable group. No patient having

carcinoma of the common duct survived over five years, yet one patient lived for fifty-two months.

From this experience, as judged by the late results following pancreatoduodenal resection for carcinoma, we now believe that if one discovers any evidence of extension or metastases to regional nodes, the operation is not worth while. We have found that if one carries out a resection with the limits of resection going through invaded tissue, death can be anticipated within a few months, as will be noted from the figures for 23 patients having resection for carcinoma of the head of the pancreas who lived less than one year. It is our practice to advise and carry out pancreatoduodenal resection in any patient in whom the lesion seems to be localized, irrespective of its site in the head of the pancreas, ampulla, duodenum or common duct. While survival for a period of over five years for carcinoma of the head of the pancreas is a rarity, it is necessary to resect these lesions not only for whatever benefit can accrue, but also to get the more favorable lesions involving the ampulla. The fact that 3 patients having carcinoma of the ampulla are living over eight years is encouraging.

SUMMARY

Experience with pancreatoduodenal resection for carcinoma of the ampulla, head of the pancreas, duodenum and common bile duct are presented. A one-stage pancreatoduodenal resection can usually be carried out, but in patients having long-standing obstruction of the common duct, a two-stage procedure should occasionally be employed. The first-stage procedure, as described, of cholecystojejunostomy does not add materially to the technical difficulties of the second-stage procedure and does permit rapid improvement of liver function as a result of the relief of obstructive jaundice.

The technic of pancreatoduodenal resection has been described with particular emphasis on the means of confirmation of the diagnosis at operation and determination of operability.

Seventy-nine pancreatoduodenal resections are reported with 10 deaths, an operative mortality of 12.6 per cent.

An appraisal of pancreatoduodenal resection, based on the site and extent of the lesion, is presented. Three patients having resection for carcinoma of the ampulla survived over eight years.

From our experience, pancreatoduodenal resection should be reserved for those cases in which the malignant disease is still localized, without local extension or regional node metastases.

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AN APPRAISAL OF PANCREATODUODENAL RESECTION

A Follow-up Study of 61 Cases

RICHARD B. CATTELL AND LUDWIG J. PYRTEK

The operation of pancreatoduodenal resection has been performed for thirteen years, since it was first reported by Whipple[1] and associates in 1935. Large numbers of patients have been operated on during this period. Their course has been followed for a sufficient time to permit evaluation of the procedure when employed for carcinoma of the head of the pancreas, carcinoma of the ampulla, carcinoma of the duodenum and carcinoma of the lower end of the common bile duct. The operation as described by Whipple was the first attempt to apply the general principles of radical cancer surgery to these serious and relatively inaccessible lesions. A few large series of cases have been reported by Whipple,[2] Orr,[3] Waugh and Clagett,[4] Waugh,[5] Bartlett[6] and Cattell.[7]

In the six-year period from August 1942 to August 1948, 165 patients with carcinoma in the region of the head of the pancreas were observed at the Lahey Clinic, and on 56 of these a pancreatoduodenal resection was performed. During this time 5 additional patients had pancreatoduodenal resections for benign disease, giving a total experience for pancreatoduodenal resection of 61 cases. Careful follow-up studies have been made on every one of the resected cases.

Basing our data on a review of this experience, we have attempted to answer certain logical questions that have arisen, which can be stated as follows: (1) What patients are suitable for resection? (2) Should a one-stage or a two-stage operation be employed? (3) Is it essential to anastomose the pancreatic duct? (4) Can carcinoma of the ampulla be cured? (5) Is it worth while to resect carcinoma originating in the head of the pancreas? (6) Can a reasonable operative mortality be obtained? (7) Does pancreatoduodenal resection offer sufficient palliation in extensive cases to be worth while?

Too few series of cases have been followed for the generally accepted period of five years to judge curability on this basis. In our own series, only 12 patients were operated on more than five years ago. Orr,[3] in 1945, collected 103 cases from the literature, including 11 personal cases, and of this group found that no patients survived over three years. Waugh,[5] reporting a follow-up study of 30 cases in which operation was performed at the Mayo Clinic, reported that 1 patient who had had a carcinoma of the ampulla survived for three years. Bartlett[6] reported 25 cases from the Massachusetts General Hospital and found 1 survival of five years.

From August 1942 to August 1948 at the Lahey Clinic, 165 patients with carcinoma of the head of the pancreas, ampulla of Vater, duodenum and lower end of the common bile duct were treated (Table 1). Fifty-six patients were

Originally published in Annals of Surgery, 129.840–848 (June) 1949. J. B. Lippincott Co., publishers.

submitted to pancreatoduodenal resections, an operability rate of 34 per cent. During this time 2 additional patients with carcinoma arising in a hyperfunctioning pancreatic adenoma were submitted to local resection. These 2 patients have previously been reported by Allan and Marshall.[8] Most of the remaining patients had exploratory laparotomies and palliative procedures such as cholecystojejunostomy.

Fifty-six cases of pancreatoduodenal resection for carcinoma were divided according to the location of the lesions (Table 2). In 20 the lesion arose in the ampulla. In 2 the lower end of the common duct was the primary site, while

Table 1. Pancreatoduodenal Resection—Operability (1942–1948)

Patients with carcinoma	165
Pancreatoduodenal resections	56 (34%)
Local resections	2

4 had a primary lesion of the duodenal mucosa near or about the ampulla of Vater. A somewhat larger number, 30, apparently arose in the head of the pancreas, usually thought to be in the duct of Wirsung. In this latter group the process was frequently diffuse, making the point of origin impossible to determine. Three patients were submitted to pancreatoduodenal resection with an operative diagnosis of carcinoma of the head of the pancreas; in these the lesions were found to be benign. These patients were excluded from the group of 56 operated on for carcinoma and included in the 5 operated on for benign disease. The other 2 were operated on with the diagnosis of benign disease.

Table 2. Pancreatoduodenal Resection—Pathology

Carcinoma of ampulla	20
Carcinoma of head of pancreas	30
Carcinoma of duodenum	4
Carcinoma of common duct	2
Total	56

Among the patients submitted to resection were both favorable and unfavorable cases. Particularly in our earlier experience, some extensive carcinomas of the head of the pancreas were included in which it was known at the conclusion of the operation that all the malignancy was not excised. These included patients with involvement of the superior mesenteric vessels, invasion of the portal vein and retroperitoneal extension. Regional node involvement, likewise, was frequently demonstrated, particularly at the inferior angle of the common bile duct and the duodenum, as well as those nodes superior to the duodenum in the gastrohepatic omentum. Our experience with these cases of more extensive malignant disease has been unsatisfactory and led us to discontinue resection in these unfavorable cases. It is now our opinion that when local invasion or metastases to lymph nodes are present, operation should not be advised.

The operation of pancreatoduodenal resection may be done in one or two

stages. Whipple,[1, 2, 9, 10] in his extensive experience, began with a two-stage operation and now feels that the one-stage operation can be done. Trimble,[11] Orr,[3] Waugh[5] and Brunschwig[12] likewise favor the one-stage operation. In our experience with 61 pancreatoduodenal resections (Table 3), at the Lahey

Table 3. Pancreatoduodenal Resection—Operation

One-stage operation (including 5 benign)	25 (40%)	4 deaths
Two-stage operation*	36 (60%)	5 deaths
Total	61	

* 10 patients had first stage done elsewhere.

Clinic, 25, or 40 per cent, were done in one stage. This includes all 5 resections for benign lesions. Thirty-six patients, or 60 per cent, were operated on by a two-stage operation, 10 of these having had their first stage done elsewhere. The first-stage operation which we recommend is a cholecystojejunostomy utilizing a long antecolic loop of jejunum. The second stage is delayed for from two to three weeks, during which time the condition of the patient greatly improves. In our experience, this procedure does not add appreciably to the technical difficulties of the resection. We believe that the employment of the two-stage operation has enabled us to extend the operation to patients who would not otherwise be suitable risks for such a major procedure. Furthermore, it permits surgeons who do not choose to carry out the radical procedure to perform a first-stage operation at the time of their exploration. From our own experience, we believe that the employment of the two-stage operation has been the most important factor in maintaining a low mortality.

The two-stage operation is employed in patients with long-standing jaundice, in those with marked enlargement of the liver and in the group representing the poorest surgical risks. If the gallbladder has previously been removed or is unsuitable for the anastomosis, choledochostomy is satisfactory for a first stage. It adds considerably to the technical difficulty of the resection, but may be the wise procedure.

The technic of operation will not be presented in this paper. The operation that we usually employ has recently been presented.[13] The one-stage operation which we prefer has all anastomoses in an antecolic position and they consist of end-to-end gastrojejunostomy, enteroenterostomy, pancreatojejunostomy and choledochojejunostomy (Fig. 306, *b*). The enteroenterostomy may be avoided by implantation of the stomach distal to the pancreatic and biliary anastomoses and then become an end-to-side gastrojejunostomy (Fig. 306, *a*). In the two-stage operation, the common duct is turned in (Fig. 307, *a* and *b*) or if its division is close to the entrance of the cystic duct, it is implanted in the jejunum beside the cholecystojejunostomy. Anastomosis of the end of the jejunum to the common duct with implantation of the pancreas and stomach below the biliary anastomosis, as employed by Whipple and Waugh, has been utilized (Fig. 308, *b*). This may be reversed so that the end of the jejunum is joined to the pancreas (Fig. 308, *a*).

The operative mortality following pancreatoduodenal resection has varied

in the reported series from 11 to 45 per cent. In the 56 resections for carcinoma in our series, there were 8 deaths, a mortality of 14.3 per cent. In addition to this, there were 5 resections for benign disease, with 1 death, or 20 per cent. This 1 death occurred in a patient who was operated on with the mistaken

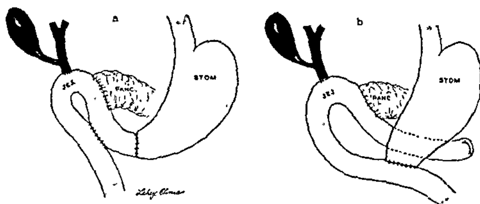


Fig. 306.

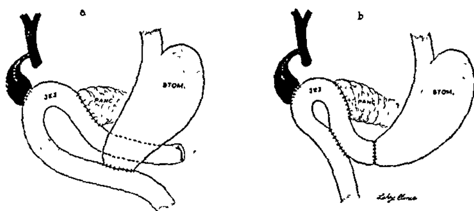


Fig. 307.

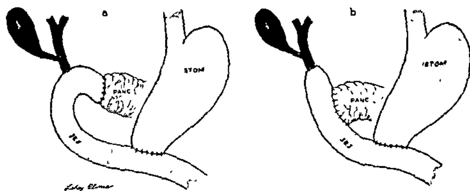


Fig. 308.

diagnosis of malignant disease. In Table 4 the operative deaths are recorded, based on the site of the lesion. Of the 9 patients who were submitted to resection for carcinoma of the ampulla in one stage, there were no deaths. Eleven had a two-stage operation, with 1 death. In the total series of 20 patients with carcinoma of the ampulla, there was 1 death or a 5 per cent mortality. It must be remembered that these are the most favorable lesions.

There were 9 patients with carcinoma of the head of the pancreas who had resection in one stage with 3 deaths, and 21 were done in two stages with 2 deaths, a total of 30 with 5 deaths, or a mortality rate of 16.7 per cent. Four patients with carcinoma of the duodenum had resection, with 2 deaths. These occurred in the 3 patients submitted to a two-stage operation. A one- and a two-stage operation were each done for carcinoma of the common duct, without a fatality.

Table 4. Pancreatoduodenal Resection—Operative Mortality

	Cases	Deaths	Per Cent
1-stage carcinoma, ampulla	9	0	
2-stage carcinoma, ampulla	11	1	
	20	1	5.0
1-stage head of pancreas	9	3	
2-stage head of pancreas	21	2	
	30	5	16.7
1-stage carcinoma, duodenum	1	0	
2-stage carcinoma, duodenum	3	2	
1-stage carcinoma, common duct	1	0	
2-stage carcinoma, common duct	1	0	
Total	56	8	14.3

In the interpretation of these results it should be appreciated that the patients who were the most serious risks, those with the greatest interference with liver function, were operated on in two stages. We feel that this mortality rate of 14.3 per cent for malignant disease, 14.8 per cent including benign disease, is evidence in favor of a two-stage operation for the deeply jaundiced individual.

The causes of death in fatal cases are seen in Table 5. Fatal gastrointestinal hemorrhage occurred in 2. The site of bleeding could not be determined. Generalized peritonitis was found in 2 patients. In one the pancreatic anastomosis had separated. In this patient, metastases were found in the retroperitoneal region and also in the lungs. One patient died of surgical shock with possible transfusion reaction; this was the patient who had resection with a mistaken diagnosis of cancer. One of the patients early in the series died as a result of sepsis with liver abscess occurring nine weeks after operation. Death followed one-stage resection in a case with an hepatorenal syndrome and associated renal

Table 5. Pancreatoduodenal Resection—Fatal Cases

Gastrointestinal hemorrhage	2
Peritonitis	2
Liver abscess	1
Shock	1
Hepatorenal syndrome	1
Cerebral thrombosis	1
Coronary thrombosis	1

suppression. The cause of death in another was cerebral thrombosis in a poor-risk patient with arteriosclerotic heart disease and hypertension. Coronary insufficiency and thrombosis caused death during operation in a 77 year old man with a favorable lesion of his ampulla.

The duration of life following the onset of cancer in the region of the head of the pancreas is quite short. In an earlier report,[14] we found in 56 consecutive patients who were operated on prior to 1935, in whom cholecystojejunostomy was performed, that 75 per cent were dead within six months of the operation. A review of our patients submitted to pancreatoduodenal resection definitely demonstrates that life can be prolonged when the operation is performed in suitable cases and that some patients may be cured. Only a small group in this series was available for a five-year follow-up study. During 1942, 2 resections were done, and during 1943, 10 resections were performed, making a total of 12 patients whose course has been followed for five years. One patient with carcinoma of the ampulla is living and well after six years and two months; the second is in good condition for five years and seven months, and a third, five years and five months after operation. All had adenocarcinoma of the ampulla of Vater without extension. Of the patients who had recurrent disease and subsequently died, 1 who had carcinoid of the ampulla lived four years and seven months and 2 others with carcinoma of the ampulla without metastases lived three years and four months and three years and two months, respectively. Thus, in this small series of 12 cases, 3, or 25 per cent, of those submitted to resection five years or more ago are living and well, while 6, or 50 per cent, lived three years or more.

Table 6. Pancreatoduodenal Resection—Five-year Survival

1942	2	1*	6 years, 2 months
1943	10	2*	5 years, 7 months
	Recurrent Cases		
1 (carcinoid)			lived 4 years, 7 months
1*			lived 3 years, 4 months
1*			lived 3 years, 2 months
	50% (6) lived 3 years or more		
	25% (3) living and well		

* Carcinoma of ampulla.

It seems worth while to report the three-year survival rate in our series. For the years 1942 to 1945, 27 of the 56 patients had resection. Of these, 8, or 30 per cent of the group, lived three years or more. The 2 patients with carcinoma of the duodenum surviving resection lived two years and eight months respectively. The 2 with carcinoma of the common duct lived three years and five months and one year and nine months, respectively.

There were 30 patients with carcinoma of the head of the pancreas submitted to resection, with 5 fatalities. This left 25 patients, all of whom have had follow-up studies. Eighteen were found to be dead of recurrence, with an average duration of life of eleven months after resection. The longest duration of life was nineteen months. Seven patients are still living, as follows: three

years and seven months, two years and three months, one year and three months, one year, and three patients have been followed for less than one year.

This relatively short survival time after pancreatoduodenal resection for carcinoma of the head of the pancreas is the most discouraging finding in all of our experience with these cases. It is a similar observation to that of the other recorded series. It must be admitted that no patient with carcinoma of the head of the pancreas has yet been cured or survived five years or more. While may of these patients have a smooth recovery and are quite comfortable for a number of months, the duration of their life following resection hardly justifies such a major procedure since satisfactory palliation might have been procured by a sidetracking operation, such as cholecystojejunostomy, for the relief of obstructive jaundice. In the light of our present experience, we must modify the operative procedure or abandon radical surgery for carcinoma of

Table 7. Pancreatoduodenal Resection—Three-year Survival, 1942–1945

1942	2	1
1943	9	5
1944	6	0
1945	10	2
	—	—
1942–1945	27	8 (30%)

the head of the pancreas. We have observed rapid peritoneal dissemination with carcinomatosis in patients in whom the line of resection passed through malignant tissue, and it is quite possible that in some unfavorable cases we have hastened death rather than delayed it. We can certainly assume that resection for extensive cases of carcinoma of the head of the pancreas or those with local direct extension or regional metastases should no longer be considered for resection. Even with apparently very favorable lesions confined to the duct of Wirsung, we have seen recurrence as early as nine months. An isolated observation by Cole[15] may explain early recurrence with favorable lesions. He found malignant cells free in the obstructed duct of Wirsung and it is possible that dissemination of cancer occurs by cutting across the duct, with the escape of pancreatic fluid. Before discontinuing radical pancreatectomy for carcinoma of the head of the pancreas in favorable cases, we wish to suggest the employment of total pancreatectomy in which this possible complication could be avoided. It has not yet been employed under these circumstances in our clinic. According to our present understanding of this problem, the employment of total pancreatectomy in early carcinoma of the head of the pancreas offers the only chance of a possible improvement of these results.

We have undertaken a survey of the nonfatal complications as well as physiologic studies on patients after resection but these will not be reported in this paper. An excellent study of 10 cases has been recently reported by Wollaeger[16] and others.

From our experiences with 61 pancreatoduodenal resections, including 56 for carcinoma, and 5 for benign disease, the following points have been answered. (1) The operation is technically feasible as it has been developed.

(2) With proper selection of cases and the employment of a two-stage operation in selected cases, the operative mortality can be maintained at a reasonable level, one similar to that for other gastrointestinal cancers. (3) Physiologic functions so far as the gastrointestinal tract and pancreatic and liver function are concerned can be established and maintained. (4) Carcinoma of the ampulla can be cured in an appreciable number of cases. (5) Pancreatoduodenal resection should be confined to favorable lesions. (6) Carcinoma of the head of the pancreas has not yet been cured. (7) The operation of pancreatoduodenal resection as now employed is suitable for carcinoma of the ampulla. Pancreatoduodenal resection for carcinoma of the head must be modified or discarded.

CONCLUSIONS

A series of 61 pancreatoduodenal resections performed at the Lahey Clinic has been reported. Fifty-six were employed for carcinoma in the region of the pancreatoduodenal area and 5 were performed for benign disease.

Twenty patients with carcinoma of the ampulla were operated on, with 1 death, a 5 per cent mortality. Thirty patients with carcinoma of the head of the pancreas had resections, with 5 deaths, a mortality rate of 16.7 per cent. Fifty-six resections for carcinoma were done, with 8 deaths, or 14.3 per cent. Five resections for benign disease were done, with 1 death, 20 per cent. Sixty-one resections were followed by 9 operative deaths, 14.8 per cent.

Twenty-five patients, 40 per cent, had pancreatoduodenal resection as a one-stage procedure. Thirty-six, 60 per cent, were operated on in two stages.

Of 27 patients having pancreatoduodenal resections for carcinoma, 8 (30 per cent) survived three years or more.

Of 12 patients followed for five years or more, 3 show no evidence of recurrence. All had carcinoma of the ampulla of Vater. The longest period a patient was followed was six years and two months.

Pancreatoduodenal resection should be reserved for those patients with favorable lesions.

Carcinoma of the ampulla may be cured by pancreatoduodenal resection.

Carcinoma of the head of the pancreas has not been cured by pancreatoduodenal resection. A more extensive operation, such as total pancreatectomy, should be carried out or resection for this condition should be abandoned.

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PHEOCHROMOCYTOMA: ITS DIAGNOSIS AND TREATMENT

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Pheochromocytoma, an epinephrine producing tumor, although rare, occur with sufficient frequency (approximately 200 reported to date) to war a suspicion of its presence in a patient having any type of vasomotor attack nonthyroid hypermetabolism or both. The suspicion of such a tumor plus help of a few pointed clinical studies will lead to the correct diagnosis, an carefully executed surgical procedure aided by one of the new adrenolytic di (dibenamine-benzodioxan) will bring about a cure. The patient with pl chromocytoma may be entirely asymptomatic prior to a fatal attack but it is v the "spell-inciting" or hypermetabolism-producing tumors that this paper de Four such cases have been observed during the last three years. These 4 c present all of the ramifications of the clinical entity of pheochromocytoma all 4 patients were successfully operated on.

During the three-year period in which these 4 cases were diagnosed clinic and the tumors successfully removed, we have encountered 2 postopera fatalities due to unrecognized pheochromocytomas. One patient died follow lumbar sympathectomy for peripheral vascular disease, a severe hypertens reaction developed during the course of the operation and was followed by ac heart failure and death. The second patient had an incisional hernia repair a similar reaction and death occurred. During this same period of time we kn of 2 additional similar deaths in one of our hospitals, one during a thora operation and the second at the conclusion of a gastrectomy. In all 4 case pheochromocytoma was found at necropsy and was unquestionably the ca of death.

Should a hypertensive reaction occur during the course of any operative p cedure it should lead to the suspicion of a pheochromocytoma. Based on our perience it must be emphasized that this reaction constitutes an acute emerger not unlike cardiac arrest, and one should be prepared to meet it, just as we ha prepared ourselves to manage cardiac arrest. One of the following courses m be instituted.

1. Immediately stop the operation and after the patient's recovery, subr him to further investigative study.

2. If the operation is intra-abdominal, immediately explore the adrenals a sympathetic chain areas, and if a tumor is found, steps should be taken to pr ceed with its removal.

3. Use an adrenolytic drug to control hypertension and continue with t initial operation. Postoperative investigation should then be carried out to co

Originally published in Annals of Surgery, 131:903–916 (June) 1950. J. B. Lippinc Co., publishers.

firm the presence of pheochromocytoma. (The response of the blood pressure to the adrenolytic drug is additional confirmatory evidence.)

In the light of our present knowledge and with the use of the new adrenolytic drugs, it now seems that one is justified in proceeding with exploration to make certain whether or not a pheochromocytoma is present.

CASE 1.* A 23 year old woman gave as her complaint recurring attacks, 5 to 6 times daily and lasting one to fifteen minutes during the previous three years, of weakness, severe throbbing headache, dyspnea, palpitation, epigastric and substernal pain, nausea and vomiting, unsteadiness and blotchiness of the skin. The attacks usually came after eating and at times were relieved by vomiting or sneezing. Between the attacks she was perfectly well. During the previous two years thyroidectomy, appendectomy and cholecystectomy had been performed and teeth removed in the hope of stopping the attacks.

The pulse rate was 120 and blood pressure 102 mm. systolic and 94 mm. diastolic. Shortly after admission to the hospital she had one of her typical attacks during which the blood pressure was 180 mm. systolic and 120 mm. diastolic. This led to the suspicion of a pheochromocytoma.

The blood sugar during an attack rose from 100 to 166 mg. per 100 cc. An intravenous pyelogram showed a depression of the left kidney. The basal metabolic rate was +9 when the blood pressure was 112 systolic and 80 diastolic, and +36 during a typical attack with the blood pressure 200 systolic and 110 diastolic. Histamine and mecholyl diagnostic tests were carried out and found to incite a typical attack with a systolic pressure of 200 and diastolic pressure of 140.

Exploration of the right adrenal area gave negative results. A tumor, 8 cm. in diameter, was found in the left adrenal area and was removed. During its removal a severe hypertensive reaction with circulatory collapse occurred, from which the patient recovered. The tumor weighed 260 gm; the pathologic diagnosis was pheochromocytoma.

The patient remained well for one year and then a swelling developed in the right side of the neck. Biopsy revealed this to be a metastatic pheochromocytoma. The blood pressure had remained normal and the mecholyl test was negative. Radical neck dissection was carried out, followed by roentgen ray treatment.

It is now three and a half years since the pheochromocytoma was removed and one and a half years since radical resection of the neck was performed. Her physician reports that the patient's health has failed gradually; she has severe neck pain which requires narcotics for relief, indicating advancing metastatic disease. She has had no further hypertensive attacks.

CASE 2.† A 24 year old woman gave as her chief complaint blindness, which began five months before admission to the clinic, during the fourth month of pregnancy. The blood pressure was found to be elevated when the eye symptoms first began. During the sixth month of gestation convulsions developed for which she was hospitalized. She remained semicomatose for three weeks, then labor was induced and a dead fetus delivered. Recovery was slow; the blood pressure remained at a high level and there was no improvement in vision. Following discharge from the hospital she failed to regain her strength. She perspired at times and had frequent episodes of flushing and forceful pounding of the heart.

On examination, the blood pressure was 180 systolic and 136 diastolic with a pulse rate of 110. A firm mass was found in the left side of the pelvis. The retinal vessels

* Previously reported by Guarneri and Evans.
† Previously reported by Bartels and Kingsley

were markedly constricted and scattered areas of old exudate and pigmentary degeneration were seen.

Because the intravenous pyelogram disclosed slight delay in the emptying time of the right kidney, retrograde pyelography was undertaken. The blood pressure before induction of anesthesia with intravenous sodium pentothal was 120 systolic and 80 diastolic. Simultaneously with the injection of dye into the right ureter the blood pressure rose to 190 systolic and 150 diastolic, followed by profound circulatory collapse (Fig. 313). Recovery gradually took place during the next five hours.

Following this procedure, the blood pressure was found to fluctuate widely. It was not unusual to obtain a reading of 120 systolic and 80 diastolic and then within a minute or two the patient flushed and perspired and the blood pressure climbed to a level of 200 systolic and 150 diastolic. Because of the extreme variability of the blood pressure and inability to obtain basal readings of sufficient duration to permit the performance of specific diagnostic tests, it was decided to carry out the necessary tests under avertin anesthesia. The histamine test was negative but the mecholyl and etamon tests were positive.

Since the diagnosis of pheochromocytoma seemed certain, it was decided to explore the lower part of the abdomen to determine the nature of the pelvic tumor and then palpate the adrenal areas. The left ovary was found to be involved in a cystic mass, and this was removed. Then palpation revealed a tumor mass in the region of the left adrenal gland. This tumor was successfully removed by retracting the stomach, colon and pancreas During the operation the blood pressure remained normal. The pathologic diagnosis was pheochromocytoma.

On the second day after operation the patient became confused, lethargic and word aphasic. This cleared in 10 days. A lumbar puncture disclosed clear yellowish fluid under increased pressure; the total protein was 55 mg. per 100 cc.

On the fourteenth postoperative day the histamine and mecholyl tests were negative.

Six months after operation the patient was in excellent health except for visual impairment and slight residual word aphasia. The blood pressure was 124 mm. systolic and 80 mm. diastolic. She has had no further attacks.

CASE 3.* A 30 year old married woman complained of attacks of substernal distress and palpitation for ten years, profuse perspiration and lifetime intolerance to heat. Her illness actually began at the age of 9 years when, because of excessive perspiration and 30 pound weight loss, she was suspected of having hyperthyroidism. She was given roentgen ray treatment to the thyroid gland. Because of sugar in the urine, insulin was given for a time. At the age of 20 she became pregnant and because of hypertension (200) and albuminuria, a therapeutic abortion was done. The blood pressure fell to normal. Following the pregnancy she began to have attacks of substernal pain with radiation into the arms and neck, lasting from several minutes to an hour. These attacks were associated with fear of impending death, profuse perspiration, marked palpitation, dyspnea and oftentimes a severe occipital pounding The attacks were followed by prostration which lasted for hours.

When the patient was 22 years of age, because the basal metabolic rate was found to be +60, a subtotal thyroidectomy was performed. This did not relieve the symptoms, which were diagnosed as angina. The blood pressure was never taken during an attack.

At the age of 30, because of continued attacks, intolerance to heat, excessive perspiration and an elevated basal metabolic rate, +30 and +41, the patient was referred to the Lahey Clinic.

The blood pressure varied between 180 and 110 mm. systolic and 100 and 80 mm.

* Previously reported by Bartels and Arnold.

diastolic. No thyroid remant was palpable. She perspired periodically, and with this there was a slight rise in the pulse and blood pressure. The urine did not reveal sugar but the glucose tolerance test indicated diabetes. A roentgenogram of the chest showed arteriosclerotic changes in the arch of the aorta. An intravenous pyelogram demonstrated calcification about the upper pole of the right kidney.

Histamine, given intravenously, produced some increase in the systolic and diastolic blood pressure but did not incite an attack. The epinephrine test produced a rise in both the systolic and the diastolic pressure and symptoms similar in every respect to those of the mild attacks. The mecholyl test produced a rise in blood pressure to 190 mm. systolic and 110 mm. diastolic but did not produce an attack.

When the tests were carried out under intravenous pentothal, the histamine and mecholyl tests gave negative results. Under avertin anesthesia, intravenous etamon produced a fall in the blood pressure but there was no overshoot. All efforts to provoke an attack were unsuccessful.

The basal metabolic rates were +60, +58, +62 and when taken under pentothal were +53 and +60.

Since the available evidence, in spite of negative provocative tests, favored a pheochromocytoma, exploration was deemed advisable. The left adrenal area was first explored and found to be normal. Exploration of the right side revealed a large tumor arising from the right adrenal gland.

During the operation, palpation of the tumor produced a rise in the blood pressure to 180 systolic and 126 diastolic with a rise in the pulse of 170. Dibenamine (60 mg.) was given at this time; the blood pressure returned to 120 systolic and 90 diastolic but the pulse remained 140. The tumor was removed. It weighed 75 gm. and microscopically was found to be a pheochromocytoma.

After operation all of the patient's complaints were relieved and have not returned (10 months) and for the first time in her life she has experienced chilliness. The blood pressure and basal metabolic rate were normal, as were the glucose tolerance test, histamine, mecholyl and cold pressor tests.

CASE 4. A 20 year old girl was well until eight months before being seen, when morning occipital headaches began. One month later she noted *continuous excessive* sweating and palpitation at night. In the seventh month of her illness the blood pressure level was found to be very high, and the basal metabolic rate was elevated (+37 and +40). Because of the suspicion of thyroid disease she was referred to the Lahey Clinic for study.

Physical examination revealed the skin to be warm and moist. The pulse rate was 120 and the blood pressure 200 systolic and 130 diastolic. The thyroid was not palpable.

The glucose tolerance curve was typically diabetic. An intravenous pyelogram showed very slight downward displacement of the left kidney. The dibenamine test was positive, the blood pressure falling to a normal level (130 systolic and 90 diastolic) during the intravenous administration of 182 mg. of dibenamine. The basal metabolic rate was +42.

The hypermetabolism without hyperthyroidism, the diabetic glucose tolerance test and the positive dibenamine test seemed to confirm the diagnosis of a pheochromocytoma and the slight downward displacement of the left kidney placed the tumor on the left side.

Exploration of the left adrenal area revealed the tumor, but before it was removed the right adrenal area was explored by opening the peritoneal cavity, and found to be normal. The tumor, a cystic mass, was then removed. It measured 6 cm. in diameter.

On microscopic study it was found to be a paraganglioma. During the course of the operation dibenamine was given intravenously, which maintained the blood pressure at a subhypertensive level; a total of 175 mg. was given.

The patient's postoperative course was satisfactory. The blood pressure was normal and all symptoms were relieved. A follow-up examination six weeks after operation revealed a normal blood pressure, a normal glucose tolerance test and a basal metabolic rate of +10.

SYMPTOMS

The duration of symptoms in 2 cases was four to eight months, in 1 case three years and in 1 case twenty years. Attacks or "spells" with vasomotor manifestations constituted the outstanding symptoms (Fig. 309) in 3 of our 4 cases.

	CASES 1	2	3	4
A CARDIOVASCULAR ATTACK	+	+	+	−
B SWEATING		+	+	+
C BLOOD PRESSURE				
1 FLUCTUANT	+	+	+	
2 SUSTAINED				+
D ELEVATED BMR	+		+	+
E DIABETIC G T TEST	+(*)		+	+
F ABNORMAL I V PYELO	+		+	+

(*) ELEVATED BLOOD SUGAR DURING ATTACK

Fig. 309. Essential symptoms and clinical findings in Cases 1 to 4.

Palpitation was noted in all 4 cases and sweating was periodic in 2 and constant in 2 patients. Two patients suffered from substernal pain with dyspnea during an attack which had the characteristics of angina pectoris. Occipital headache was noted by 2 patients. Blotchiness of the skin was observed by 1 patient during a typical attack. Blindness, developing during the early months of pregnancy, was the chief complaint of 1 patient. Three of the 4 patients, because of known hypermetabolism, were previously considered to have thyroid disease. Two of these patients (Cases 1 and 3) had been submitted to subtotal thyroidectomy without benefit, and the third patient was sent to the clinic for a thyroidectomy.

CLINICAL FINDINGS

One patient (Case 4) had sustained hypertension, 2 patients (Cases 1 and 2) were observed during typical hypertensive attacks and 1 patient (Case 3) had mild fluctuant hypertension.

Three patients were studied from the standpoint of the basal metabolic rate. Case 1 (Fig. 310) had a normal metabolic rate when the blood pressure was normal but the rate was +35 when taken during an hypertensive attack. Case 3 had metabolic rates ranging around +60 during periods of near normal blood pressure. Even under pentothal anesthesia the rate remained elevated, +55. Case 4 had sustained hypertension, the basal metabolic rate ranging from +35 to +42.

Case 3 illustrates that the basal metabolism can be elevated even during periods of normal blood pressure.

Intravenous pyelograms were sufficiently abnormal in 3 patients to indicate the probable site of the pheochromocytoma. In 2 cases slight downward displacement of the kidney gave the clue and in 1 patient there was calcification of the tumor.

Abnormal sugar metabolism was observed in 3 patients. Case 1 had a rise in the blood sugar of from 100 to 166 mg. during an hypertensive attack. Cases 3 and 4 had suggestive diabetic glucose tolerance tests (Fig. 311). Glycosuria was not a feature of any of the cases.

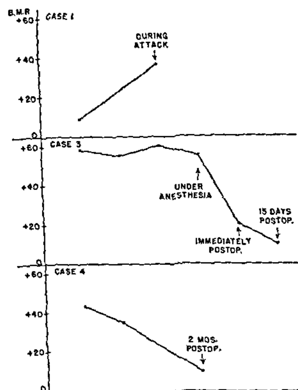


Fig. 310.

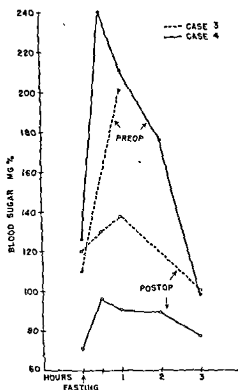


Fig. 311.

Fig. 310. Basal metabolic rates before and after removal of pheochromocytoma in Cases 1, 3 and 4.

Fig 311. Glucose tolerance tests before and after removal of pheochromocytoma in Cases 3 and 4.

SPECIFIC DIAGNOSTIC TESTS*

1. **Histamine.**[9] Case 1 developed a typical hypertensive attack following the intravenous administration of histamine (0 05 mg.). Case 2, because of the ease of attacks and our failure to obtain a near normal base line of blood pressure for study, was given histamine when under pentothal anesthesia (Fig. 313, *B*). This test gave negative results. Case 3 also had a negative histamine response under pentothal anesthesia (Fig. 314, *b*). When the test was carried out in the usual way there was a very slight blood pressure rise (Fig. 315, *a*) but

* See Figure 312.

an attack was not incited and the systolic pressure rose only to 180 and the diastolic to 110. These experiences with histamine indicate that this drug is not a specific test for pheochromocytoma since an attack may not be incited by its use and also, pentothal anesthesia may nullify its effect. The explanation for this failure of histamine to cause a reaction while the patient is under pentothal is not apparent but it does suggest that histamine acts through the emotional cen-

	CASES 1	2	3	4
HISTAMINE	+	−*	± −*	
MECHOLYL	+	+*	± −*	
ETAMINE		+*	−*	
DIBENAMINE				+

* UNDER ANESTHESIA

Fig. 312 Specific diagnostic tests in Cases 1 to 4.

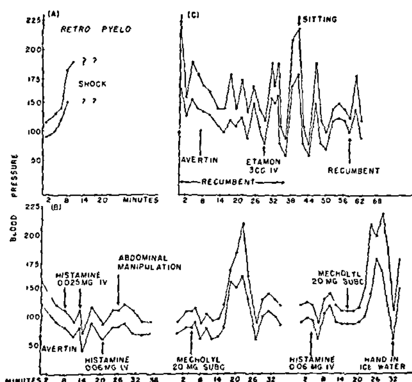


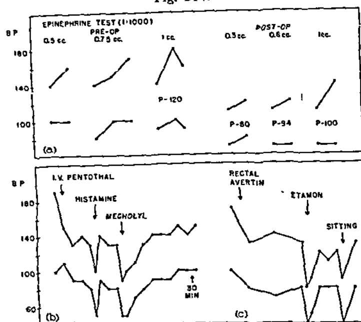
Fig. 313 (Case 2) Hypertensive reaction at the time of pyelogram (*A*), and response to specific tests under anesthesia (*B* and *C*).

ter in stimulating the pheochromocytoma since histamine given intravenously does produce very unpleasant head symptoms.

2. **Mecholyl.**[7] In Case 1 a characteristic hypertensive attack followed the subcutaneous administration of 15 mg. of mecholyl. Case 2 was given mecholyl while under pentothal anesthesia (Fig. 313, *B*), with a characteristic pheochromocytoma response (systolic pressure 210, diastolic 150, a diastolic hypertensive response). Case 3 (Fig. 315, *c*) had some rise in the blood pressure which was very gradual but it did not greatly exceed the basal blood pressure

l the patient did not experience symptoms such as she had during her attacks. hen the test was done under pentothal anesthesia the test (Fig. 314, *b*) was

Fig. 314.



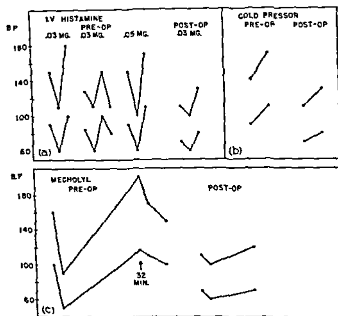


Fig. 315.

Fig. 314 (Case 3). Response: *a*, to epinephrine before and after operation; *b*, to histamine and mecholyl when patient is under intravenous pentothal, and *c*, to etamon while under avertin anesthesia.

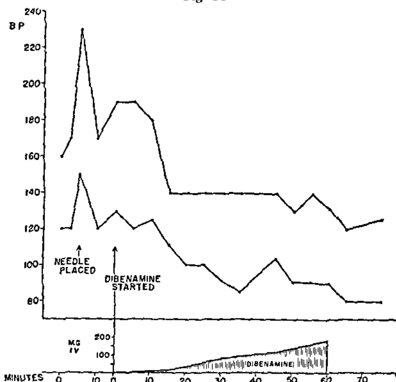
Fig. 315 (Case 3). Response of blood pressure: *a*, to histamine before and after operation; *b*, to cold pressor tests before and after operation, and *c*, to mecholyl before and after operation.

completely normal; a sufficient fall took place following the injection but no abnormal rise followed.

These experiences with the mecholyl test indicate that it is a diagnostic aid

since in the first 2 cases it was positive. In the third case, however, it was negative, indicating that it is not a specific test for pheochromocytoma.

Fig. 316.



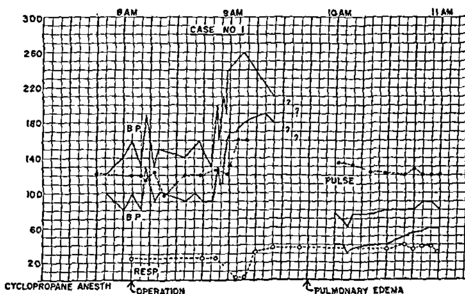


Fig. 317.

Fig. 316 (Case 4). Response of blood pressure to intravenous dibenamine.
Fig. 317 (Case 1). Hypertensive reaction during course of removal of pheochromocytoma with pulmonary edema indicative of acute heart failure.

3. **Etamon.**[8] In Case 2, 3 cc. of etamon was given intravenously (Fig. 313, *C*), under avertin anesthesia. It produced a severe, almost precipitous systolic and diastolic hypertensive response which, after the initial rise, became wavelike during the next twenty minutes. In Case 3, when the etamon was

given while the patient was under avertin narcosis (Fig. 314, c) the test was negative; a prompt fall occurred following the administration of etamon but no subsequent abnormal rise took place. As with histamine and mecholyl, etamon is not a specific incitatory hypertensive agent in the presence of a pheochromocytoma and a negative response does not rule out the presence of a tumor.

4. **Dibenamine.**[11] Because of sustained hypertension dibenamine was used as a diagnostic aid in Case 4. After the blood pressure (Fig. 316) had reached a base line of 190 systolic and 120 diastolic, a 0.6 per cent solution of dibenamine was begun intravenously. After fifteen minutes the systolic pressure fell to 140, with a slower fall in the diastolic pressure, reaching 90 only after 30 minutes. The lowest blood pressure was reached at one hour, on termination of the test, when the systolic pressure was 120 and the diastolic 80. A total of 182 mg. of dibenamine was administered. This test was strong evidence for a pheochromocytoma as reported by Spear and Griswold.[11] Benzodioxan,[5] another adrenolytic agent, has been reported to be an equally informative agent but its use may cause an alarming hypertensive reaction in patients who do not have a pheochromocytoma.[4]

Since most of the previously mentioned studies are carried out on hypertensive patients in preparation for sympathectomy, we have been able to rule out the possible presence of pheochromocytoma in this type of patient. Smithwick has reported pheochromocytoma to be a finding in 0 5 per cent of his cases of hypertension in which sympathectomy is performed.

SURGICAL TECHNIC

Operation for pheochromocytoma is best carried out under general anesthesia utilizing ethylene-ether or cyclopropane-ether administered through an endotracheal tube. Spinal anesthesia should be avoided because of its direct effect on the blood pressure. Since even induction of anesthesia may precipitate an hypertensive reaction, an intravenous needle should be inserted previous to anesthesia to permit rapid administration of whatever medication may be required. Only small amounts of intravenous fluid should be given and blood should be used only to replace that lost if bleeding is encountered during the procedure. Surgical shock is not an important factor and a lowering of the blood pressure, particularly after removal of the tumor, may be guarded against solely by lowering the head in the Trendelenburg position. Actually, death may result from a vigorous attempt to treat this condition as shock, with intravenous fluid and blood and cortical extract, by adding to the burden of the heart in beginning failure. In light of the present knowledge, only two measures are needed: first, an adrenolytic drug to combat the hypertensive reaction and second, Trendelenburg position to avoid cerebral anoxemia associated with the hypotension following removal of the tumor.

The operation is usually best carried out through the usual kidney incision. In the presence of a large tumor, better access is gained by removal of the twelfth rib, taking care to avoid opening the pleura. The kidney is displaced downward and medially, following which the fascia is incised to expose the adrenal. The identification of the adrenal is facilitated by avoiding exposure of the kidney.

The abdominal approach may be used for large tumors, particularly on the left side or in those cases in which general exploration is indicated, as in Case 2. There seems no reason to employ a thoraco-abdominal incision.

We believe it advisable to explore both adrenal glands, since in 10 per cent of cases the tumors may be multiple and, rarely, there may be congenital absence or atrophy of the other gland. In Cases 1 and 3 the side on which the tumor was located was determined by radiographic visualization before operation, but we explored the opposite adrenal before removing the tumor. It should be recognized that with a hyperfunctioning medullary tumor the opposite adrenal will not show atrophy, contrary to the findings in hyperfunctioning cortical tumors in which atrophy is observed on the opposite side. In Case 4, the side on which the tumor was situated was explored and, before its removal, the opposite adrenal was palpated by opening the peritoneum through the kidney incision. It must be appreciated that this method of exploration may be unsatisfactory. The tumor in Case 2 was removed through an abdominal approach because of a known ovarian tumor. The approach to the left adrenal is similar to that to the tail of the pancreas through the gastrocolic omentum.

In the delivery of the tumor compression should be avoided. The vessel pedicles are dissected and clamped as early as possible to avoid the release of excessive amounts of epinephrine, as noted in Case 1. The amount of adrenolytic drug found during diagnostic studies to be necessary to lower the blood pressure or to prevent the hypertensive reaction can be given intravenously before dissection of the tumor.

Partial or total adrenalectomy should be carried out depending on the exploratory findings. It may be possible to save appreciable portions of the involved adrenal in carrying out the resection of the tumor. If invasive characteristics are noted, the extent of the operation should be determined by the findings, and probably should include nephrectomy. These tumors may be malignant, as in Case 1, in which metastases were found in the cervical nodes removed by radical neck dissection.

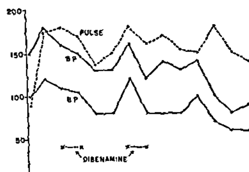
The dramatic and fearsome experiences with the removal of pheochromocytomas, as noted in Case 1, need no longer occur since adrenolytic drugs are now available to avoid the hypertensive reactions. This, combined with the knowledge that the hypotension that continues for a few hours following removal of the tumor need not be feared, removes the unusual danger formerly associated with these operations.

BLOOD PRESSURE RESPONSE DURING AND AFTER OPERATION

In the past great emphasis has been placed on the hypertensive state and collapse with death which may follow removal of a pheochromocytoma. This has been wrongly considered as a state of epinephrine deficiency and injudiciously treated with intravenous epinephrine Since this collapse state may occur when the pheochromocytoma is still *in situ*, it is evident that epinephrine lack is not the cause. The clinical picture is readily explained on the basis of acute left heart failure resulting from excessive circulating epinephrine, which causes extreme, increased peripheral resistance comparable with that obtained when a surgical clamp is placed on the ascending aorta. One of us[3] (E. C. B.) first

called attention to the cardiac factor responsible for this collapse state. Treating such a state with epinephrine evidences a lack of understanding as to its true cause. A severe hypertensive reaction occurred during the operation in Case 1 (Fig. 317). In Case 2 the operative course was satisfactory. Acute cardiac failure can only be prevented by taking steps to avoid prolonged hypertension during the course of operation. Of more importance is the need of some adrenolytic compound to neutralize the excess circulating epinephrine as reported by Grimson, et al.[6] We must, therefore, quickly experiment with the use of benzo-

Fig. 318.



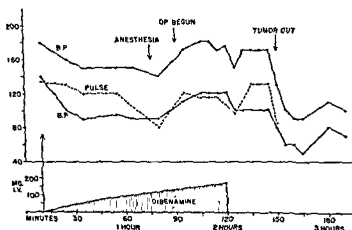


Fig. 319.

Fig. 318 (Case 3). Response of blood pressure and pulse to dibenamine during course of operation.

Fig. 319 (Case 4). Response of blood pressure and pulse to dibenamine given before and during the course of operation for removal of a pheochromocytoma.

dioxan or dibenamine during the course of operation to remove a pheochromocytoma in an effort to find a means of maintaining the blood pressure below a critical hypertensive level.

In Case 3 (Fig. 318) intravenous dibenamine was used during the course of the operation in an attempt to keep the systolic blood pressure below 150. Two short periods of intravenous administration of dibenamine were given, the total dose being 60 mg. Since the pulse remained high there is some doubt as to whether an actual therapeutic dose was given. A hypotensive reaction did not occur after operation.

In Case 4 (Fig. 319), intravenous dibenamine was first given preoperatively

to restore the blood pressure and pulse to normal. During the operation dibenamine was continued, giving a total dose of 175 mg, this being the amount which was safely administered during the diagnostic dibenamine test (Fig. 316). The blood pressure was purposely not completely restored to normal, since it was feared a possible hypotensive state might occur if the amount of dibenamine given was in excess. On removal of the tumor the blood pressure fell to 90 systolic and 45 diastolic and then gradually rose to a normal level. Further experience with these new drugs will be needed before their proper use is determined. However, they do give promise of solving the hypertensive reaction during operation to avoid serious postoperative vascular collapse.

Our 4 patients recovered from the surgical removal of the pheochromocytoma. Only Case 2 caused us concern because of a mild cerebrovascular accident with resulting slight word aphasia which was noted during the postoperative period. In the other patients the postoperative courses were without incident. The

	CASES 1	2	3	4
A LOCATION OF TUMOR SIZE	L 250 GM	L 4 CM	R 75 GM	L 6 CM
B B P NORMAL	+	+	+	+
C NO FURTHER ATTACK	+	+	+	
D B M R NORMAL			+	+
E GLUCOSE T TEST NORMAL			+	+
TESTS				
HISTAMINE		-	-	
MECHOLYL	-	-	-	

Fig 320 (Cases 1 to 4). Location, weight, or size of tumor and the results of postoperative clinical tests.

blood pressure reached a normal level in those patients with paroxysmal attacks and remained lower than at any time during the preoperative study period (Fig. 320). No further attacks occurred in any of the patients In Cases 3 and 4 in which the basal metabolic rates were studied they were normal (Fig. 310). In Case 3 the basal metabolic rate had returned practically to normal when determined immediately after removal of the tumor while the patient was still under anesthesia. In Cases 3 and 4 the glucose tolerance tests were normal when taken only a few days after operation (Fig. 311) Histamine tests were done postoperatively in Cases 3 and 4, with normal results. The mecholyl test was also normal after operation in Cases 1, 2 and 3 The hypertensive disease was decisively cured in all four cases. Only Case 1 remains in serious trouble, suffering from metastatic disease. In spite of the malignant growth, no further hypertensive attacks have occurred. Case 2 has residual sight difficulty as a result of serious vascular retinopathy.

SUMMARY

A suspicion of pheochromocytoma is justified in any patient with vasomotor attacks who has such associated symptoms as excess sweating with blotchiness

of the skin, toxemia during the early months of pregnancy, findings of fluctuant or sustained hypertension, in whom a suspicion of hyperthyroidism is present.

The salient laboratory findings aiding in the diagnosis of pheochromocytoma are elevation of the metabolic rate without goiter, abnormal pyelograms such as displaced kidney or calcification and elevated blood sugar or a diabetic glucose tolerance test.

Certain incitatory substances such as histamine, mecholyl or etamon are helpful in making the diagnosis of pheochromocytoma. These tests, however, are not specific and must be carefully carried out for proper interpretation. Dibenamine and benzodioxan are also helpful in those patients with pheochromocytoma who have sustained hypertension but sufficient experience has not proved their safety.

The chief danger from surgical removal of pheochromocytoma is a severe hypertensive reaction with subsequent acute left heart failure. This danger can probably be avoided by using an adrenolytic agent during the operation. More experience is necessary before these drugs can be intelligently utilized.

Removal of the tumor leads to cure unless the tumor (pheochromocytoma) is malignant and leads to metastatic disease or has already produced serious vascular damage.

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THE BREAST

CARCINOMA OF THE BREAST: TECHNIC OF RADICAL MASTECTOMY

SAMUEL F. MARSHALL

Since the introduction of radical surgical treatment for cancer of the breast by Halsted and Willy Meyer over fifty years ago, radical mastectomy has been the most effective method of treatment of this condition. We have employed the Halsted method of radical mastectomy at the Lahey Clinic for a number of years and, although this method has been modified somewhat, it essentially follows the basic principles laid down by Halsted in the development of this operation. Both Halsted and Willy Meyer emphasized the need for the removal of the breast, pectoral muscles and the tissues of the axilla in one block. The operation should consist of excision of the breast together with the skin over the entire breast, excision of both pectoral muscles and complete resection of the lymph nodes and areolar tissue of the axilla. During the past ten years, however, in addition to radical mastectomy, we have employed deep roentgen therapy postoperatively, which we believe has aided materially in increasing the five-year survival rates after operation. Before the employment of irradiation therapy only 38.6 per cent of all patients having radical mastectomy (this included those with and those without axillary node involvement) survived operation five years or more. Hare and I have reported on the results of this combined treatment for the first five-year period. In spite of the high incidence of involvement of axillary nodes, there was material improvement in the five-year survival rates with the combined treatment. This rate had risen from 38.6 per cent to 52.1 per cent for the entire group in spite of the fact that 62 per cent of these patients had metastases to the axillary nodes at the time of operation. Of the group without axillary involvement 75 per cent survived for five years and of those with axillary involvement at the time of radical mastectomy 37 per cent were alive and well at the end of five years.

While the value of x-ray therapy combined with radical mastectomy may be a debatable question in the minds of some surgeons, in any case it is our opinion that there has been definite improvement in the results of treatment of cancer of the breast by this combined method, but we believe that further information must be collected from a much larger group of patients treated in a similar manner over a long period of time before any definite conclusions can be drawn. It must be emphasized, therefore, that radical mastectomy still is the most important method of treatment, but that postoperative x-ray therapy is also a valuable adjuvant to radical surgery.

In an effort to permit earlier application of x-ray therapy we have been more conservative in removing skin over the chest wall during the radical operation

Originally published in Surgical Clinics of North America, 29:727–737 (June) 1949.

in order that primary closure can be done and radiation treatment started immediately after operation. Halsted emphasized the importance of wide removal of skin and covering the chest defect with a Thiersch graft. It is evident from our experience with more conservatism in regard to skin removal that the frequency of development of local recurrent growth has not increased as might be expected from previous reports in which wider removal of skin was thought to be absolutely necessary. Lewis and Rienhoff, in an article from Johns Hopkins, reported that local recurrences after Thiersch grafts took place in 30.1 per cent, and after a closed plastic procedure, in 39.7 per cent. In the group of 238 cases that we studied in which radical mastectomy was carried out and postoperative radiation therapy was given, only 8 per cent of these patients had recurrence of malignant disease in the scar area, supraclavicular and axillary regions, and this, too, in a group of which 62 per cent showed secondary malignant involvement in the axillary nodes at the time of operation. In view of this, we have been more conservative in the amount of skin removed at the time of radical mastectomy; we rarely remove more than 5 or 6 cm. of skin beyond the edge of the palpable malignant tumor. In the majority of cases plastic closure of this wound has been carried out. Only occasionally has a Thiersch graft proved to be necessary.

We have not employed simple mastectomy routinely. It is used occasionally only as a palliative measure in removing an ulcerating, advanced malignant growth and, in addition, x-ray therapy is employed as a palliative measure. Occasionally it is necessary also to use simple mastectomy in elderly individuals who are poor surgical risks or patients who have serious cardiac disease or other debilitating diseases that would make a radical mastectomy hazardous. Since a large percentage (37 per cent) of patients with involvement of the axillary nodes can be free of the disease for a period of five years or more, radical mastectomy should be utilized for all patients if at all possible. Simple mastectomy is of no value for those patients who have involvement of the axillary nodes.

We have not confined our treatment of cancer of the breast to a selected group of cases that might possibly present a more favorable prognosis. Radical mastectomy is employed in all cases in which the cancer is still confined to the breast and to the corresponding axilla. The principal contraindications to radical surgery are the presence of distant metastatic tumor, involvement of the lungs, pleura or bones or extension to the supraclavicular nodes or to the opposite breast.

ANESTHESIA

Many types of anesthesia have been used but we have gradually come to employ nitrous oxide and ether anesthesia, which can be continued over a long period of time without serious difficulties arising from the anesthetic agent. At the beginning of operation an intravenous needle is placed in the long saphenous vein in either ankle, this permits medication, fluids or blood transfusion to be given during the operation. It is much safer to provide for intravenous medication early rather than to wait until shock develops and then attempt to find a vein in order to introduce fluid or blood.

INCISION

The type of incision employed at the clinic is a simple encircling incision with a vertical extension above and below the breast, which in the majority of cases permits ready access to the contents of the axilla and chest wall. Many types of incision for radical removal of the breast have been employed and perhaps all have proved useful and each is advantageous in the hands of the particular surgeon who is accustomed to his own type of radical mastectomy. The

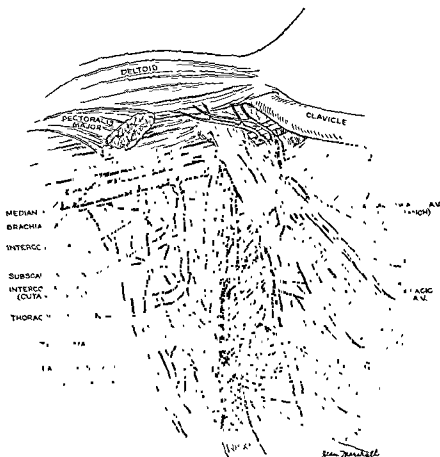


Fig. 321. The anatomy of the axilla. The relationship is shown of the pectoral muscles to the vessels and nerves encountered in axillary dissection for radical mastectomy.

type of incision in a large measure depends upon the location of the tumor in the breast. We have not used the incision which Halsted described in his earliest reports; this incision extends out upon the arm and produces a band of scar tissue across the axilla, thus interfering materially with restoration of arm motion. A simple transverse incision described by Stewart is often useful. Although exposure of the axillary contents is not quite as complete as with the vertical incision, thorough dissection of axillary contents can be made and this incision permits an extremely easy plastic closure of the wound, and heals readily. It is a particularly valuable type of incision for tumors located in the extreme lateral borders of the breast.

Greenough's arrowhead incision[5] permits an excellent approach to the axilla and is a valuable type of incision for those tumors which arise high in the axillary extension of the breast.

OPERATION

The operative field is cleaned with zephiran, the skin of the affected side is painted well beyond the midline anteriorly and also onto the back, and the arm also is painted with zephiran to the elbow. The arm is abducted and outstretched on a narrow arm board. The arm usually can be fastened to the arm board since there is little occasion for changing its position during the opera-

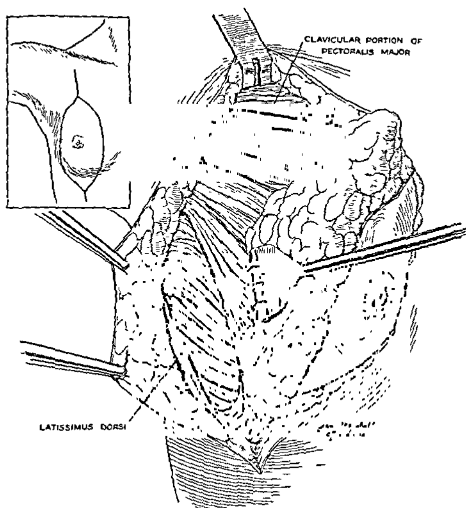


FIG. 322. The type of breast incision used is shown in the insert It consists of an encircling incision about the breast and its tumor; the incision is extended vertically above and below the breast. Following the outlining of the incision, the medial and lateral skin flaps are dissected away, exposing the latissimus dorsi laterally and the pectoralis major muscle. The breast is retracted medially during this dissection. The dissection is carried downward, exposing the sheath of the rectus muscle, and extends above over the insertion of the pectoralis major muscle onto the humerus. The line of division between the clavicular and pectoral portions of the pectoralis major muscle is clearly seen at the upper end of the incision.

tion. The skin incision is outlined about the breast and an incision is carried through the skin to the subcutaneous tissue and fat (Fig. 322). The skin incision is extended above the breast toward the shoulder to the level of the clavicle and below, about 7 or 8 cm distal to the inframammary fold of the breast. The lateral skin flap is dissected first, removing all fat and subcutaneous tissue; nothing but skin is left in the flap.

The dissection is begun at the lower end of the incision and is carried down

over the abdomen until the fascia over the rectus and external oblique muscles is exposed. The incision is then carried laterally until the edge of the latissimus dorsi is exposed, this dissection being carried toward the shoulder, exposing the edge of the latissimus dorsi up to the edge of the pectoralis major muscle and beyond, over the muscle to the clavicle. All bleeding points are ligated with fine black silk which is used as ligature material throughout the operation.

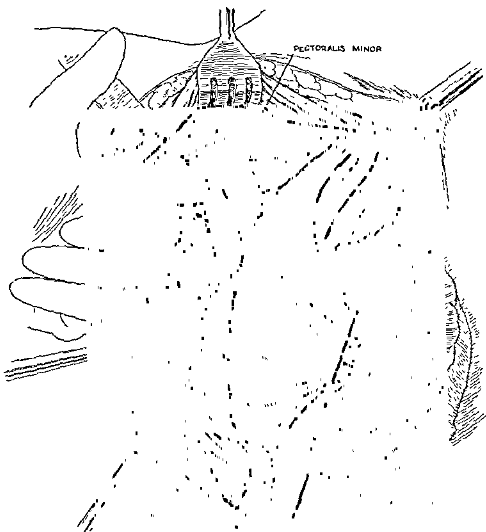
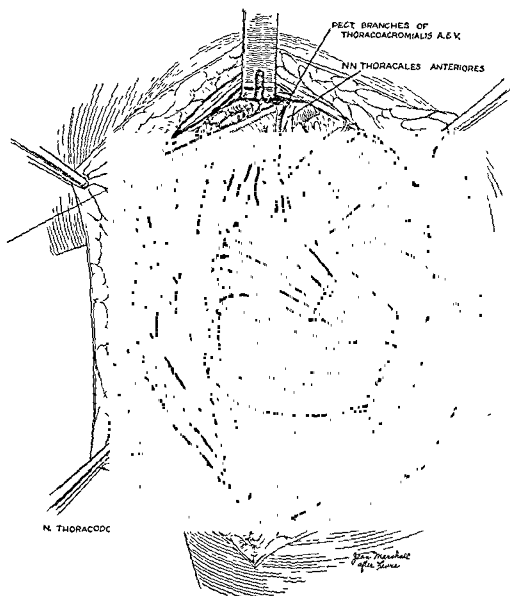


Fig. 323. The pectoralis major muscle has been divided at its insertion [illegible] and is retracted medially. The pectoralis minor muscle is e[illegible] and the point of division at its insertion on the coracoi[illegible] pectoralis minor muscle exposes the entire axilla for a clean dissection of its fat and node elements.

The medial skin flap is dissected similarly, the dissection being carried from below upward and to the midline of the sternum up to the level of the clavicle. At the upper end of the incision the fascia of the pectoralis major is exposed below the clavicle, and both the clavicular and pectoral portions of the pectoralis major muscle may be removed. If the tumor is not located in the upper half of the breast or is not extensive, however, the muscle may be split between the costal and clavicular portions, which makes the removal of the pectoralis major muscle much easier and less hemorrhagic (Fig. 323). The splitting of the

muscle is carried to the insertion of the pectoralis major muscle on the arm and the tendon of the pectoralis major muscle is divided near its attachment to the humerus and retracted medially over the chest wall. By medial retraction



over the brachial plexus are also dissected cleanly and this sharp dissection with removal of lymphoid and areolar tissue is carried out into the axilla. As each vessel is clamped and divided, it is tied immediately with fine black silk. Note the dotted line which illustrates the line of severance of the pectoralis major muscle from the thoracic wall. The entire mass consisting of breast, muscle and fatty tissue is retracted laterally to complete the dissection from the chest wall. This mass is removed *en bloc,* together with all the gland, areolar and fatty tissue of the axilla.

of the pectoralis major muscle, the coracoclavicular fascia covering the pectoralis minor muscle and the axillary vessels and contents are exposed. The coracoclavicular fascia fuses with the sheath of the axillary vessels, blends medially

with the fascia covering the first and second intercostal interspaces, invests the pectoralis minor muscle and continues laterally to join the axillary fascia.

The coracoclavicular fascia is incised with a knife and the pectoralis minor muscle is exposed (Fig. 324). This muscle is dissected up to its point of insertion at the coracoid process and divided and retracted down and medially. Then the removal of the pectoralis major and minor muscles together with the breast mass from the chest wall can be proceeded with, beginning above at the clavicle and proceeding downward onto the rectus sheath. If tension is kept on the pectoral muscles the perforating branches of the internal mammary vessels are readily seen and can be clamped, divided and ligated. Very little bleeding occurs if these vessels are exposed and secured before they are torn and divided. As the sheath of the rectus and the external oblique muscle are approached, a portion of the rectus sheath is removed together with the muscle, exposing the fibers of the rectus muscle. The mass of skin, breast and pectoral muscles can then be retracted laterally and stripped from the chest wall. If a little tension is kept on the mass, the operation is bloodless and the mass can be separated cleanly from the ribs, intercostal muscles and serratus muscles. The dissection is continued to the junction of the posterior and lateral walls of the axilla, removing all fatty tissue, until the border of the latissimus dorsi is reached. The dissection is continued along the edge of this muscle.

Following the removal of the pectoral muscles, the axillary contents are completely exposed and the loose connective tissue, fat and embedded lymph nodes are removed by sharp dissection with a knife. The subclavian vein is exposed at its highest point beneath the clavicle and all of the lymph nodes, areolar tissue and fatty contents are cleanly removed by sharp dissection from the subclavian and axillary vessels. The mass of areolar and gland tissues is removed from above downward, dissecting close to the vein and ligating all vessels immediately with fine black silk to prevent the clamps from being torn from the vein by their own weight and to remove them from the operative field. All tissue along the subclavian and axillary vessels as well as over the brachial plexus is removed cleanly. As the breast mass and muscle mass are retracted laterally during the dissection, the intercostobrachialis and intercostalis nerves which emerge below the second, third and fourth ribs are exposed and divided. Just posterior to these nerves the long thoracic nerve, which lies closely along the chest wall and innervates the serratus, is exposed. This can readily be identified and should be preserved along the chest wall.

The dissection is carried laterally until the subscapular vessels and long subscapular nerve are exposed. The vessels are divided and ligated and the subscapular nerve, if involved with the tumor and lymph nodes, should be removed also. Usually, however, it can be preserved but its removal does not appear seriously to disturb the motion of the arm. We have frequently removed it without disability in those cases in which many nodes are found along the course of the nerve.

The mass of breast and muscle tissue is now retracted medially by an assistant and, with gentle traction, the vessels along the exposed edge of the latissimus dorsi are readily seen, clamped, divided and ligated, thus preventing trouble-

some hemorrhage which may greatly interfere with clean dissection of the axilla. The areolar tissue and nodes between the latissimus dorsi and chest wall are thoroughly cleaned from the muscle and chest and removed, together with the entire block of breast and muscle tissue (Fig. 325).

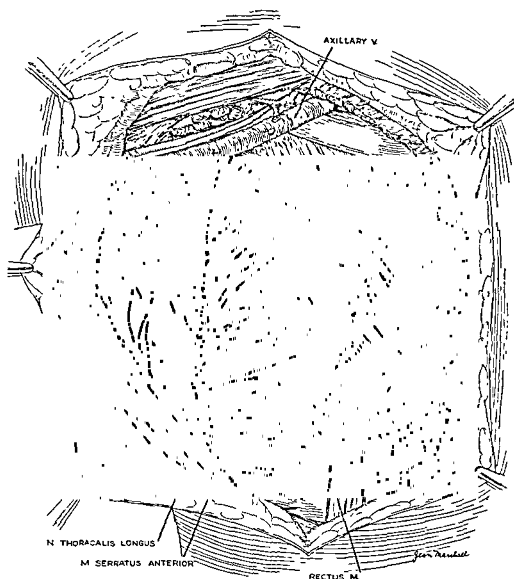


Fig. 325. The completed operation. The subclavian and axillary vessels have been stripped cleanly of their fatty and areolar tissue. Note that the fascia of the rectus muscle has been removed and the chest wall cleaned thoroughly, allowing the thoracalis longus and thoracodorsalis nerves to remain. All of the fat, glandular and areolar tissue are removed between the latissimus dorsi and the serratus muscles. This completes the operation. Careful hemostasis is obtained before wound closure and the skin edges are approximated with interrupted sutures of fine black silk.

The wound is carefully inspected for bleeding and all bleeding points are ligated so that the wound in most cases is thoroughly dry. During the operation the chest wall is covered with moist, warm gauze pads to prevent undue exposure and consequent shock. If dissection is carried along methodically, all vessels can be exposed, hemostasis obtained and blood loss can be kept at a minimum so that shock rarely occurs.

The wound is closed by approximating the skin edges with interrupted sutures of fine black silk. No subcutaneous sutures or retention sutures are used and trauma to the skin flap is carefully avoided so that there is no further interference to the already much decreased blood supply. Following closure of the wound, the skin flaps are allowed to fall naturally in place over the axillary defect and are held in place by pressure from soft fluffed gauze and dressing pads. The arm is bandaged firmly to the side of the chest and the forearm is placed across the body in a sling. We do not employ drainage of the axilla and in the majority of cases healing takes place primarily without the accumulation of serum. If serum does occur it may be aspirated easily with a sterile needle introduced between the stitches and, if careful hemostasis has been carried out during the operation, there is very little development of serum. The skin edges can be approximated in the majority of cases and plastic closure of the wound obtained, but should this not be possible we do not hesitate to apply a Thiersch graft to the remaining exposed portion at the time of the radical mastectomy. We prefer plastic closure, however, as stated previously, so that postoperative x-ray therapy may be started as early as possible.

POSTOPERATIVE MEASURES

The patient usually is able to sit in a chair by the end of the second day. The arm is released within twenty-four hours, partly abducted but fully extended by passive motion. This can be accomplished without great distress to the patient. The range of motion is easily obtained by early passive motion of the arm. There has been no ill effect on wound healing and no separation of skin flaps from the chest wall as the result of early motion.

There are few cases, indeed, in which radical mastectomy cannot be done with a great margin of safety. In a group of 238 consecutive radical mastectomies there was only one postoperative death which resulted from coronary occlusion. As stated previously, patients are allowed up in a chair as early as possible, usually by the end of the second day, encouraged to exercise the arm early, and usually before radiation treatment is started almost all patients have practically complete range of arm motion.

Radiation treatment with deep x-rays is usually started within ten days to two weeks after operation, when we have deemed the healing of the chest wound to be satisfactory. Treatment is delivered to the scar, the axilla and the supraclavicular areas. As an initial dose, 300 roentgen units is given to each portal, treating one portal daily for three days. Following this, each portal is treated daily with 100 r until 2400 r has been delivered to each of three portals, for an overall dosage of 7200 r.

There has been no material interference with wound healing by giving this deep x-ray therapy soon after operation. Only moderate skin reaction to x-rays has occurred and pulmonary changes such as radiation pulmonitis have not resulted. Mild erythema and desquamation do occur following this form of treatment, but they are limited to the axilla and the scar area; they usually reach a peak within fifteen to twenty-one days and the erythema fades gradually until the skin is normal, except for pigmentation, at the end of eight weeks.

After radical mastectomy and deep x-ray therapy for carcinoma, the course

of these patients is followed at regular intervals and they are examined once every three months during the first two years. After the first two years, they are examined at six-month intervals until the end of five years. This examination should include fluoroscopy of the chest and, in the event of any suspicion of recurrence in the form of chest or skeletal metastases, roentgenograms of the skeletal system or of the chest are obtained.

The postoperative five-year survival rates are good, there being 75 per cent five-year survival of those patients without involvement of nodes and 37 per cent five-year survival of those who have involvement of nodes.

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CARCINOMA OF THE BREAST: RESULTS OF COMBINED TREATMENT WITH SURGERY AND ROENTGEN RAYS

SAMUEL F. MARSHALL AND HUGH F. HARE

Since the introduction of radical surgical treatment for cancer of the mammary gland by Halsted and Willy Meyer, radical mastectomy has been the method most commonly employed by the medical profession to treat patients with this type of malignancy. In spite of the fact that radical dissection has approached the acme in the thoroughness of removal of the mammary gland, with its tumor and the surrounding structures of the chest wall and axilla, yet the five-year clinical survival rate has remained relatively stationary and the reported results of treatment of breast carcinoma in the literature have shown a discouraging lack of improvement in the number of patients surviving five years after radical operation.

Carcinoma of the breast in the female, like carcinoma of the female pelvic organs, is one of the most frequent causes of death resulting from malignancy. The United States Bureau of Vital Statistics gives a death rate of 12 per 100,000, and the yearly death rate from this type of malignant disease is approximately 16,000 (Table 1).

This high death rate from cancer of the breast each year is a direct challenge to the medical profession and the divergent opinions as to the best method of treating an operable cancer of the breast are evidence of the dissatisfaction with the low survival rate after various methods of treatment. Every effort to increase the salvage of these patients, whether by operation or irradiation, is worth the greatest consideration.

That our experience with postoperative results at the Lahey Clinic has been quite similar to other published results is illustrated by a review of a series of patients operated upon prior to 1936 in this clinic. Only 38 6 per cent of all patients having radical mastectomy (the majority of this group had no irradiation treatment) survived operation five years or more. These results very closely parallel the figures on results given by Haagensen and Stout[6] in the treatment of patients with carcinoma of the breast at the Presbyterian Hospital, in New York, over a period of twenty years; they reported a five-year clinical cure of 36.1 per cent after radical mastectomy.

With these facts in mind and since we could apparently not hope, at least in our hands, to improve the survival rate of patients with surgical removal alone no matter how radically or how skillfully the operation could be done, we added to the already radical amputation of the breast, a course of intensive and thorough roentgen therapy applied after operation. Accordingly, beginning in 1935, a uniform method of treatment was outlined and employed whenever possible

Originally published in Annals of Surgery, 125 688–702 (June) 1947. J. B. Lippincott Co., publishers.

for all patients with breast carcinoma coming to the Lahey Clinic. This method has been used routinely by us since 1935. It is our purpose in this paper to report the results obtained in this group of patients who have thus been treated, dating from 1935 to 1941, and who have survived a minimum of five years or longer without recurrence of tumor. From these results we hoped to draw some conclusions relating to the value or disadvantage of this type of combined treatment. In brief, the treatment has consisted of a Halsted-type of radical amputation of the breast followed by intensive roentgen therapy given in divided doses.

During this period (1935–1941) 283 patients with carcinoma of the breast have received some type of treatment, either radical or simple mastectomy, with irradiation, or some other form of palliative treatment, and of this group, 238 patients have had the complete treatment, that is, radical operation followed by intensive irradiation. Twenty-eight patients have had simple mastectomy, many of whom also had roentgen therapy after operation. It is that group of patients (238) who received the combined method of treatment of radical surgery and irradiation, however, with which we are most concerned in this review.

Although this series of patients is relatively small (238) compared to reports of some larger series of patients, we believe this study to be of value, since these patients have all received the same type of treatment and have been carefully followed and thoroughly studied, and from these data we believe we are justified in attempting to draw some conclusions regarding the efficacy of this combined treatment.

Since 1942 a much larger group of patients has been similarly treated but these patients have been treated too recently to report five-year survival.

In this series we have not attempted to confine our treatment to a selective group of cases that would present a more favorable prognosis but have employed radical operation in all cases in which the cancer was still confined to the breast and to the corresponding axilla. In fact, subsequent pathologic examination of axillary nodes was positive for axillary extension in 62 per cent of the cases. The only contraindication to radical surgery was evidence of distant metastatic spread, involvement of the pleura, of the lungs, bones, or extension to the supraclavicular region.

In general, the radical operative procedure employed has been the method advocated by Halsted, with minor modifications. It has consisted of removal in one block of the breast with its overlying skin, together with excision of the pectoralis major and minor muscles and thorough dissection of axillary contents and fatty and fibrous tissue of the chest wall, including a considerable portion of fascia covering the rectus muscle.

Many types of incisions have been employed by various surgeons; all have proved useful and each is probably advantageous in the hands of the particular surgeon who is accustomed to his own type of radical mastectomy. The type of incision employed depends to a large measure upon the location of the tumor in the breast. We have used the incision that Halsted later adopted instead of the incision extending out upon the arm which he first described in his earliest report on radical removal of the breast.

This incision consists of a circular incision about the breast with a vertical

incision extending above and below the breast which, in the majority of cases, permits complete access to the contents of the axilla and chest wall.

The extension of the incision on the arm is unnecessary for exposure of the axillary contents and is likely to result in a contracted scar in the axilla, which may greatly limit return of arm motion. Stewart's simple transverse incision is often useful, and permits sufficient exposure of axillary contents and allows an easy plastic closure of the wound. It is particularly valuable for tumors located in the extreme lateral border of the breast. Greenough's arrowhead incision permits



Fig. 326 Operative wound ten days after radical mastectomy. Incision consists of encircling incision, with incision extended vertically above and below the breast. Note extent of range of motion and primary wound healing ten days after operation. Deep radiation therapy can be started immediately at this stage.

an excellent approach to the axilla in those tumors which arise high in an axillary extension of the breast, where it may be used most advantageously. We have intentionally limited the extent of the skin excised, removing the skin over the breast and placing the line of skin incision about 5 to 6 cm. from the border of the tumor. This has been done in an effort to obtain a primary plastic closure of skin over the chest wall in order to obtain early healing so that irradiation treatment could be started immediately after radical operation (Fig. 326). Roentgen therapy is started as early as possible, in most cases within eight or ten days after operation. We have thought that wide excision of skin would involve closure of the defect with immediate Thiersch graft, which would greatly prolong healing and seriously delay the institution of radiation therapy.

There are few cases, indeed, in which radical mastectomy cannot be done with a great margin of safety. In this group there was only one postoperative death, which resulted from a coronary occlusion. Following radical mastectomy, these patients are allowed up in a chair on the second or third day. They are encouraged to exercise the arm early and before radiation treatment is started almost all have complete range of motion.

Simple mastectomy has been employed in 28 patients, and only in those patients whose constitutional condition would not permit a radical surgical procedure; in some it was used to remove a large ulcerating lesion or as a palliative procedure in advanced malignancy. Of this group of 28 patients only 3 have survived five years, and this is to be expected since this operation, in main, was employed palliatively in advanced cancer. In view of the fact that a fairly large group of patients (37 per cent in this report) with axillary involvement can be salvaged by radical mastectomy, there is no logical reason to employ simple mastectomy as a method of routine treatment, as is advocated by many surgeons, and such a method of treatment is to be heartily condemned. Particularly is this true with early carcinoma of the breast, as it is at this time that carcinoma should be treated most vigorously and radical operation has the greatest opportunity to accomplish a cure.

It is unnecessary to state that employment of postoperative roentgen therapy does not represent a new method of treatment as the literature[12,13] contains many reports of groups of patients treated with roentgen rays postoperatively, but with few exceptions the roentgen dosage has been small, or has been unrecorded, and seldom has there been reported a series of cases in which a uniform method of such combined treatment has been employed.

IRRADIATION TREATMENT

In 1935, when high voltage shock-proof roentgen-ray equipment became available, it was our opinion that the value of postoperative radiation for carcinoma of the breast was a debatable question. The seriousness of the disease in question, the need of more vigorous treatment and the frequency of recurrence of the disease made it seem feasible to outline a course of treatment to be given as soon after operation as was possible and to run a series of cases in which operation and radiation would be on a routine basis. The surgical plan which was carried out on this series has been given. Radiation treatment was started within ten days to two weeks following the operation, when we deemed the healing of the wound was satisfactory. Treatment was delivered to the scar, axillary and supraclavicular regions. In all cases a uniform plan of treatment was carried out, using the following factors: 200 k.v.p., 1 mm. copper filtration, distance 50 cm., portal size 15 cm. round cone, daily dose 300 r. As the initial dose 300 r was given to each portal treating one portal daily for three days. Following this, each portal was treated daily with 100 r, until 2,400 r had been delivered to each of three portals for an over-all dose of 7,200 r, all measurements taken in air. By giving this postoperative radiation in this manner, there was no material interference with wound healing. There was only a moderate skin reaction to the roentgen-rays, and there were no resulting pulmonary

changes, such as radiation pneumonitis. The erythema and desquamation which do occur following this form of treatment are limited to the axilla and scar regions, reach a peak between fifteen and twenty-one days, and the erythema gradually fades off until the skin is normal except for pigmentation at the end of eight weeks. No local treatment other than vaseline or boric acid ointment is necessary to control the effects of radiation dermatitis. The patient's course should be followed in three weeks after treatment to determine the degree of erythema and any complications which may have arisen from the radiation treatment, and again at the eight-week period for a review of the entire problem, at which time fluoroscopy of the chest should be done to rule out radiation pneumonitis.

It is apparent from a study of our results that the combined treatment was not successful in controlling recurrence of the disease in 25 per cent of the cases, even when the disease was clinically limited to the breast region. It was unsuccessful in controlling the disease in 62 per cent of those cases in which the disease had already spread to the axilla before operation. A glance at the location of the metastatic disease, however, indicates that there was very little local recurrence or persistence of the disease unless it had spread to regional lymph nodes prior to treatment.

COMPLICATIONS OF RADIATION TREATMENT

The most frequent complication of radiation treatment is nausea, and often this is associated with vomiting. This complication may usually be avoided by giving a high caloric diet, by delaying treatment for a day or two or by decreasing the daily dose. It was not necessary to decrease the daily dose except in a very few cases.

In all cases there was a moderate skin reaction consisting of erythema and in most cases desquamation of the skin beneath the axilla where the skin from the arm rubs against the skin of the chest wall. In no case was this a serious complication; however, it should always be explained to the patient that this is going to occur and that proper healing will take place in eight weeks' time. One severe complication which follows radiation treatment over the chest wall is radiation pneumonitis, which has been entirely avoided in this series by treating with small daily doses; with realization that this may occur, it should be pointed out that the differential diagnosis is between true pneumonia, radiation pneumonitis, and secondary malignancy. It is further necessary to emphasize that these changes in the lung should never be treated by further radiation even though it should prove later on to be a recurrence of the disease, especially if the pulmonary changes come within 120 days following treatment.

In radiation pneumonitis, coughing is likely to be severe and may be difficult to control even with large doses of codeine, and in some instances heroin has been used to control the cough. In the cases in which we have seen radiation pneumonitis the effects of the disease gradually disappeared in about ninety days or less, leaving a residual fibrosis and atelectasis of the lung involved, with disappearance of cough.

PALLIATIVE RADIATION TREATMENT

The radiation treatment for carcinoma of the breast other than for postoperative localized treatment is delivered as a palliative measure for recurrence in the skin, nodes, bone or abdomen. Lesions in the lungs are usually refractory to treatment and lesions involving the cranial vault, unless small and localized, are probably best not treated unless the patient understands that the hair is to be removed as a result of treatment.

The quantity of roentgen-rays necessary to bring about relief of pain from bone lesions is relatively small and should not be given in large enough dosage to produce roentgen sickness or complications of treatment. We use a maximum of 1800 r to each area and never treat a portal larger than a 15 cm. round cone in order to avoid radiation sickness and skin damage. It is generally recognized that if the lesion is hematogenous in type and involving bone, a cure is almost impossible, although there have been several reported cases of patients living for five years, or more.

When the spread of disease is lymphatic and localized to skin a single large dose of roentgen-rays may be used if the lesion is not larger than 2 cm. It must be recognized that spread has likely taken place through other lymphatic channels before treatment is given, and many times it has spread some distance from the first-noted lesion, but it is always advisable to include at least 1 cm. of skin in the field to be irradiated in order to block-off lymphatics, and thereby stop further lymphatic spread. It is our custom to shield the remaining skin with 0.5 mm. of lead and treat with a small cone. We use superficial radiation treatent, 90 k.v.p., 20 cm. distance, and give 2,400 r measured in air at one sitting. If the lesion is larger than this, we prefer to use the divided dose technic, using 1,000 r at each treatment, for three treatments. In about ten days following this type of radiation treatment there is moderate radiation reaction, with blistering and crusting of the skin, which will persist for six to eight weeks, but, in our hands, with this type of treatment the skin usually heals well in eight weeks' time and leaves only a residual, thin, tissue paper-type of scar.

We believe that the irradiation treatment of small recurrent nodules of the skin is preferable to surgical removal, as surgery does not block surrounding lymphatics, and radiation treatment may be given without untoward reaction to the patients on numerous occasions. We have a number of patients, under observation at the present time, with scar metastases, who have been under treatment and followed for as long as three years without evidence of spread of the disease elsewhere.

USE OF ESTROGENIC SUBSTANCES FOR PALLIATION

Recently there has been much interest in the value of the treatment of advanced carcinoma of the breast by estrogenic substances, when these substances are given in relatively large doses.[5] In some cases this treatment has given remarkable relief of symptoms, such as pain, and has decreased the size of the tumor mass; occasionally, the ulceration has completely disappeared. This is contrary to our understanding of the growth of breast carcinoma, yet it is, in part, fundamentally sound because large quantities of estrogenic substances completely block pituitary secretion of follicular stimulating hormones, com-

Fig 327.





Fig. 328.

Fig. 327. Carcinoma of breast, male. Osteolytic metastases, particularly ischium on left (April 16, 1945).

Fig. 328. Same case as shown in Figure 327, seven months later, showing repair, with disappearance of ischial lesion.

Fig. 329.





Fig. 330.

Fig. 329. Roentgenogram taken October 6, 1944, showing multiple osteolytic metastases. · Fig 330. Same case as shown in Figure 329, two months later, showing healing of metastatic lesions.

monly known as FSH. Once the pituitary hormones are blocked off, healin the tumor takes place temporarily but it is only occasionally that relief ma obtained by this method for over a year. There are some observers who that carcinomas of the breast become more radiosensitive during this pe that the estrogenic substances are being given.

There is another group of scientists who are giving testosterone propio to the female in the hope of bringing about relief of symptoms. Again, this be successful in some cases but in our hands it has not given favorable res

About a year and a half ago a man, aged 60, was admitted to the Clinic lowing radical mastectomy, with numerous bone metastases. He was given mg. of estrogenic substances daily in the form of stilbestrol, with comp relief of pain and with gradual but complete healing of the bone lesion. Fi 327 shows the bone at the time administration of estrogenic substances started, and Figure 328 shows the condition of the bone seven months fol ing stilbestrol treatment. In eight months there was a gradual return of sy toms and further treatment by estrogenic substances did not give relief.

PALLIATION BY ROENTGEN STERILIZATION

In 1929, Dresser[4] reported on the value of roentgen sterilization in the t ment of bony metastases, and presented a case in which treatment had given three years previously by radiation sterilization, with resultant healin the bony lesions. This result lasted for a period of seven years. Since that there have been numerous patients in the younger group who have rece roentgen sterilization, who had obtained remarkable relief of pain and an crease in their number of useful years. There have been more patients tre who did not improve following sterilization than did. In these we add ano problem which the patient had to solve; namely, the menopause, which co at a time when she is mentally upset as a result of the tumor, a complica

Table 1. Carcinoma of the Breast—Mortality, United States Bureau of Vital Statist

	NO. OF DEATHS	RATE PER 100
1942	15,954	11.9
1943	16,140	12.0

which has been very difficult to handle in several instances. It was, there deemed necessary to attempt to analyze the histories of those who did no ceive benefit from radiation sterilization, likewise the histories of those did receive benefit from sterilization. It became apparent on reviewing t histories, and it has been reported by Sosman,[14] that radiation sterilization successful only in those cases in which the pain in the metastatic region increased, and there were associated pain and swelling of the opposite brea the time of the menstrual period. If these be used as fair criteria for stop the menstrual period, then a high percentage of patients will receive fair pa tion (Figs. 329 and 330).

Adair, et al.,[2] found that roentgen rays and surgical castration give impr ment in approximately 13 to 15 per cent, and that improvement is tempo

It has been our experience in the treatment of metastatic malignancy secondary to carcinoma of the breast that the patient is usually hopeful until the very end, is remarkably cooperative, and is usually willing to try any type of treatment suggested. It is important, therefore, that we should not give these patients any type of treatment which will make them more uncomfortable.

Each one of these patients in this study has been seen and examined by one or both of the authors in this follow-up, and we believe these statistics are as accurate as can be obtained by direct observation. Of this group of 238 patients who received the complete treatment, 52.1 per cent have survived five years or longer without evidence of recurrence (Table 2). When this figure of 52.1 per cent five-year survival is contrasted with our previous experience of 38 6 per cent five-year survival after operation alone, it is evident that there is considerable improvement in the results of treatment, and we believe this must be attributed in a large measure to the added effect of roentgen therapy, as there has been no attempt to select for the combined treatment a group of cases which might offer a more favorable prognosis. This is demonstrated by the fact that in this group of 238 patients, 62 per cent had metastases to axillary nodes at the time of operation (Table 3).

Table 2. Combined Therapy, Radical Mastectomy Plus Postoperative Roentgen Therapy Five-year Survival Rate—238 Patients

	NUMBER OF PATIENTS	5-YEAR SURVIVALS WITH NO RECURRENT TUMOR	
		Number	*Per cent*
No axillary node metastases at operation	94	71	75
With axillary node metastases at operation	144	53	37
Total	238	124	52.1

Table 3. Radical Operation with Postoperative Irradiation Five-year Survival Rate

	MEMORIAL HOSPITAL Per cent	MAYO CLINIC Per cent	LAHEY CLINIC Per cent
Axilla negative:			
With roentgen therapy	76.8	75.4	75.0
Without roentgen therapy		70.2	
Axilla metastases:			
With roentgen therapy	41 8	29.4	37.0
Without roentgen therapy		24.3	

Adair,[1] also, has stated that modern irradiation by the divided dose method after radical mastectomy has definitely increased the survival rate in his cases of cancer of the breast. His figures very closely parallel our experience in this regard. in his series, of 277 patients treated by radical mastectomy followed by irradiation, the five-year survival rate was 76 8 per cent when lymph nodes were not involved and 41.8 per cent when axillary involvement was present (65.7

per cent of his group had axillary involvement). Adair has employed 1,800 to 2,250 r per portal. Harrington,[7] of the Mayo Clinic, also reported that the five-year survival rate in a large group of cases, with and without axillary involvement, was improved approximately 5 per cent by the addition of irradiation (Table 3).

On the other hand, Haagensen, in reporting the results obtained in a series from the Presbyterian Hospital (640 with radical mastectomy), said that irradiation has not been of demonstrable value in his series. He reported a five-year clinical cure of 36.8 per cent after radical mastectomy alone, and 35.1 per cent when irradiation was used after operation. The roentgen dosage employed in this group, however, was considerably smaller than that employed by Adair, or the dosage used in our series, only 800 r per portal in three areas being used. McGraw,[10] in 412 cases from the Henry Ford Hospital, reported a five-year survival rate of 29.6 per cent in 251 patients with axillary involvement, and 64 per cent in 161 patients with negative axillary nodes. He stated that irradiation therapy was used in those patients with axillary metastases. Of 177 patients surviving five years or longer, 116 were given deep radiation therapy, with 55 per cent having no evidence of recurrent tumor; of 61 not given radiation treatment, 59 per cent are living and well, without recurrent tumor. He does not state the irradiation dosage used On the other hand, some very capable observers feel that postoperative irradiation therapy is of doubtful value. Cantril and Buschke[3] believe that radiation treatment can slow up growth locally but will have no effect upon the ultimate progress of the disease They believe that the greatest palliative accomplishment of roentgen therapy is retardation of bone metastases and alleviation of pain. This opinion seems at variance with our results since there appears to be quite definite improvement in our five-year survival rate as well as a decrease in the frequency of local recurrences.

LOCATION OF METASTASES

In studying our group of 238 cases which have been followed by us for over five years, it seems pertinent to analyze the cause of our failures and to study the location of the metastatic nodules, whether the recurrence took place as a result of lymphatic or hematogenous spread. It is quite apparent from our studies that the most common type of spread is through the lymphatics and yet, once the original lymphatic area is treated by radiation, there is only small likelihood of recurrence or persistence in the area treated.

In this series a total of 114 recurrences was noted in different individuals. Their location is listed in Table 4.

This shows that a total of 8 per cent of the cases had recurrence of their lesions in the scar area, supraclavicular and axillary regions, and in this group of cases, 62 per cent showed signs of secondary malignancy to the axilla at the time of operation. This is, indeed, a small group as compared with the recurrences in this area usually noted. It seems necessary, therefore, to treat the scar, supraclavicular and axillary regions following operation especially in those cases in which there is evidence of secondary nodular disease at the time of operation.

Haagensen and Stout[8] report local recurrence in 22.8 per cent within five years in the operative field on the chest wall and in the homolateral axilla,

It has been our experience in the treatment of metastatic malignancy secondary to carcinoma of the breast that the patient is usually hopeful until the very end, is remarkably cooperative, and is usually willing to try any type of treatment suggested. It is important, therefore, that we should not give these patients any type of treatment which will make them more uncomfortable.

Each one of these patients in this study has been seen and examined by one or both of the authors in this follow-up, and we believe these statistics are as accurate as can be obtained by direct observation. Of this group of 238 patients who received the complete treatment, 52.1 per cent have survived five years or longer without evidence of recurrence (Table 2). When this figure of 52.1 per cent five-year survival is contrasted with our previous experience of 38.6 per cent five-year survival after operation alone, it is evident that there is considerable improvement in the results of treatment, and we believe this must be attributed in a large measure to the added effect of roentgen therapy, as there has been no attempt to select for the combined treatment a group of cases which might offer a more favorable prognosis. This is demonstrated by the fact that in this group of 238 patients, 62 per cent had metastases to axillary nodes at the time of operation (Table 3).

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Adair,[1] also, has stated that modern irradiation by the divided dose method after radical mastectomy has definitely increased the survival rate in his cases of cancer of the breast. His figures very closely parallel our experience in this regard: in his series, of 277 patients treated by radical mastectomy followed by irradiation, the five-year survival rate was 76 8 per cent when lymph nodes were not involved and 41.8 per cent when axillary involvement was present (65.7

per cent of his group had axillary involvement). Adair has employed 1,800 to 2,250 r per portal. Harrington,[7] of the Mayo Clinic, also reported that the five-year survival rate in a large group of cases, with and without axillary involvement, was improved approximately 5 per cent by the addition of irradiation (Table 3).

On the other hand, Haagensen, in reporting the results obtained in a series from the Presbyterian Hospital (640 with radical mastectomy), said that irradiation has not been of demonstrable value in his series. He reported a five-year clinical cure of 36.8 per cent after radical mastectomy alone, and 35.1 per cent when irradiation was used after operation. The roentgen dosage employed in this group, however, was considerably smaller than that employed by Adair, or the dosage used in our series, only 800 r per portal in three areas being used. McGraw,[10] in 412 cases from the Henry Ford Hospital, reported a five-year survival rate of 29.6 per cent in 251 patients with axillary involvement, and 64 per cent in 161 patients with negative axillary nodes. He stated that irradiation therapy was used in those patients with axillary metastases. Of 177 patients surviving five years or longer, 116 were given deep radiation therapy, with 55 per cent having no evidence of recurrent tumor; of 61 not given radiation treatment, 59 per cent are living and well, without recurrent tumor. He does not state the irradiation dosage used. On the other hand, some very capable observers feel that postoperative irradiation therapy is of doubtful value. Cantril and Buschke[3] believe that radiation treatment can slow up growth locally but will have no effect upon the ultimate progress of the disease. They believe that the greatest palliative accomplishment of roentgen therapy is retardation of bone metastases and alleviation of pain. This opinion seems at variance with our results since there appears to be quite definite improvement in our five-year survival rate as well as a decrease in the frequency of local recurrences.

LOCATION OF METASTASES

In studying our group of 238 cases which have been followed by us for over five years, it seems pertinent to analyze the cause of our failures and to study the location of the metastatic nodules, whether the recurrence took place as a result of lymphatic or hematogenous spread. It is quite apparent from our studies that the most common type of spread is through the lymphatics and yet, once the original lymphatic area is treated by radiation, there is only small likelihood of recurrence or persistence in the area treated.

In this series a total of 114 recurrences was noted in different individuals Their location is listed in Table 4.

This shows that a total of 8 per cent of the cases had recurrence of their lesions in the scar area, supraclavicular and axillary regions, and in this group of cases, 62 per cent showed signs of secondary malignancy to the axilla at the time of operation. This is, indeed, a small group as compared with the recurrences in this area usually noted. It seems necessary, therefore, to treat the scar, supraclavicular and axillary regions following operation especially in those cases in which there is evidence of secondary nodular disease at the time of operation.

Haagensen and Stout[6] report local recurrence in 22.8 per cent within five years in the operative field on the chest wall and in the homolateral axilla,

whereas, with the combined treatment of surgery and radiation we found recurrent tumor in only 8 per cent, which figure includes the supraclavicular region as well. This lack of local skin recurrence appears most significant in our cases especially, in view of the fact that we have been more conservative in the removal of skin over the breast and chest area, in order, as stated before, that primary closure could be done and radiation treatment started immediately after operation. Certainly, it is evident by this conservatism that the frequency of

Table 4. Location of Recurrent Malignancy—238 Patients

	LAHEY CLINIC		PRESBYTERIAN HOSPITAL
	Cases	Per cent	Per cent
Spread to opposite breast	8	3.3	9.1
Spread to bone	23	9.7	17.8
Generalized spread to bone and lymph nodes	25	10.5	
Recurrence in scar	14	5.9	
Recurrence in supraclavicular region	4	1.7	13.9
Recurrence in axilla	1	0.4	6 6
Recurrence in lung	24	10.0	21.6
Recurrence in abdomen and liver	7	2.9	9.8
Recurrence in cranium	8	3.3	

local recurrent growths has not increased, as might be expected from other reports in which wider skin removal was thought absolutely necessary. Lewis and Rienhoff,[9] in a report from the Johns Hopkins series, reported local recurrences after Thiersch graft to be 30.1 per cent; after closed plastic to be 39.7 per cent. White[15] is of the opinion that a chest without a skin graft is preferable to one with a skin graft and that there is insufficient proof that the Halsted method of wide skin removal with Thiersch graft lowers the incidence of local recurrence as compared to the plastic skin closure of Handley.

Table 5. Results of Radical Mastectomy and Radiation Treatment—238 Patients

	CASES	5 YR. SURVIVAL WITHOUT RECURRENCE		DEAD WITHIN 5 YEARS		DIED WITHIN 2 YEARS AFTER OPERATION	
		Number	Per cent	Number	Per cent	Number	Per cent
Negative axilla	94	71	75 0	23	25.0	10	43.5
Axilla nodes positive	144	53	37.0	91	63 0	47	52.0
Total	238	124	52.1				

Hoopes and McGraw[8] reported local recurrence to axillary and breast areas in 20 patients out of a total of 91 (22 per cent) upon whom skin graft was done, whereas, in 139 patients with plastic closure there were 22 with recurrence in these areas, an incidence of 16 per cent.

It is also significant to note that a large number of deaths took place within the first two years following treatment. Fifty-seven patients died in the first two years (Table 5). This figure represents exactly 50 per cent of the total

number dead (114) at the end of the five-year period: 10 patients without axillary involvement at the time of operation and 47 patients with positive nodes were dead in the first two years. We could draw no conclusion concerning fertility relative to the combined therapy, yet it is significant, as to the occurrence of the disease at least, that cancer occurred in nulliparous women in 40 per cent of this group. Nathanson[11] stated that it is an accepted fact that nulliparous women have a relatively higher incidence of cancer of the breast than those who have borne children, and this high incidence of cancer in nulliparous women in this group is indicative of this fact.

The study in relation to age groups, likewise, offered no significant data; there were only 28 patients of this group of 238 with the complete treatment who were below the age of 40, and we are unable to say whether or not the usually reported high early mortality after treatment is at all altered in young women by postoperative radiation (Table 6).

Table 6. Age Incidence—238 Cases. Treatment—Radical Surgery Plus Postoperative Irradiation

AGE, YEARS	CASES	
20–30	6	28 (11.7%)
31–40	22	
41–50	79	189 (80%)
51–60	66	
61–70	44	
71–80	21	

The largest group, 189 patients (80 per cent), ranged in age from 41 to 70 years. We did not hesitate to employ radical mastectomy in the older age group, as indicated by the fact that there were 21 radical mastectomies in patients over 70, and yet in this entire group of 238 patients who had the complete treatment there was but 1 immediate death following treatment, an operative mortality of 0.42 per cent.

It is difficult in a series as small as the group reported in this paper to draw final and definite conclusions regarding this most important phase of recurrent malignant disease in breast cancer, but it does appear that immediate postoperative radiation therapy, given in adequate dosage, might well influence the occurrence of local recurrent growths, and reduce such local recurrences as well as improve the five-year survival rate. In any case, it is our opinion that there has been improvement in results of treatment of breast cancer by this method and that further information will need to be collected on a larger group of patients treated in a similar manner. We are continuing this method of treatment in the Lahey Clinic and at present have under observation a somewhat larger group of patients who have also had this type of treatment, beginning after 1942. The five-year survival rate is purely a method of measurement of results of treatment and is not the ultimate or final result in any of these cases. What the results of a long range study may be can be estimated only after many years and perhaps after the majority of patients so treated may have died either from recurrent malignant disease or from other causes.

SUMMARY

Radical surgical removal of breast carcinoma followed by intensive irradiation treatment appears to improve statistical results in cancer of the breast and offers the best possibility for prolongation of life. In a series of 238 patients who received this type of treatment, 52 per cent were alive after five years or longer, without evidence of recurrent tumor.

The incidence of local recurrent tumors is materially reduced, there being only 8 per cent of such recurrences noted in this series

Radiation therapy, given in large amounts by the divided dose method, has produced no serious complications.

We believe that failure in treatment in many cases results from spread of disease to distant areas prior to institution of treatment.

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THE PELVIS

PRESACRAL NEURECTOMY

CORNELIUS E. SEDGWICK

In 1921, Leriche introduced periarterial sympathectomy of the internal iliac (hypogastric) artery for the relief of pelvic pain, and obtained good results. In 1924, Cotte found that by sectioning the superior hypogastric plexus (presacral nerve of Latarjet) equally good results were obtained. As superior hypogastric plexus excision is a simpler procedure it has supplanted the more difficult operation of periarterial sympathectomy. Since the work of Cotte many series of cases have been reported with consistently good results. The results from this clinic have previously been reported. Marshall and Kennedy, in 1945, in a study of 100 consecutive cases reported 90 per cent complete relief of all symptoms associated with menstruation in patients with primary dysmenorrhea and 80 per cent in patients with secondary dysmenorrhea.

ANATOMY AND PHYSIOLOGY

Latarjet, in 1913, described and named the presacral nerve as a distinct nerve. Other investigators (Hovelacque, Leriche, Elaut) found the nerve to be more often a plexiform formation or network of fibers and preferred the name superior hypogastric plexus, first used by Hovelacque. However, common usage and acceptance of the terms presacral nerve and presacral neurectomy have established these terms permanently in the literature.

The fibers of the presacral nerve arise in the aortic plexus between the superior and inferior mesenteric arteries. They run over the anterior surface of the aorta and are covered by a layer of loose connective tissue and parietal peritoneum. At about the level of the bifurcation of the aorta the plexus appears as two more or less distinct trunks. The trunks deviate as a mass slightly to the left, cross the left iliac vein and follow the curve of the sacrum into the pelvis. It is important to remember that some of the fibers run posterior as well as anterior to the iliacs. The superior hypogastric plexus ends with the formation of the hypogastric nerves in the hypogastric plexus.

The presacral nerve consists of preganglionic and postganglionic fibers of the sympathetic nervous system. The preganglionic fibers come from the lower thoracic and upper lumbar levels of the intermediolateral column. The postganglionic fibers originate in the sympathetic trunks and in the preaortic ganglions. The nerves of the sympathetic system are generally considered efferent (motor) in function. According to Kuntz, there is no conclusive evidence that the sympathetic system contains afferent neurons. However, since excision of the superior hypogastric plexus in many instances relieves pelvic pain, it must be assumed that visceral afferent fibers are associated with the sympathetic nerves

Originally published in Surgical Clinics of North America, 29.861–866 (June) 1949.

and that these fibers are capable of transmitting pain impulses to the central nervous system from pelvic visceral receptors.

Apparently division of the presacral nerve does not appreciably alter any normal physiology of the pelvic organs. Fontaine and Herrmann stated that section of the superior hypogastric plexus does not alter the normal menstrual cycle, does not interfere with spontaneous parturition, does not produce glandular atrophy, chronic pelvic congestion or any disturbances of motor function of the bladder or rectum. Meigs noted minor changes in the menstrual cycle following presacral neurectomy.

SELECTION OF CASES

It is not the purpose of this paper to discuss types of dysmenorrhea and indications for presacral neurectomy. Our indications for presacral neurectomy have been described by Marshall and Kennedy (1945). Suffice it to say that patients with dysmenorrhea should be carefully selected. They should have complete study and thorough trial with conservative medical measures before the patients are subjected to this procedure. Although Haman showed that patients with dysmenorrhea have a lower pain threshold than normal women it must be remembered that dysmenorrhea is a symptom and not a disease—that presacral neurectomy is symptomatic treatment and not a form of therapy dealing directly with the cause of the symptom.

ASSOCIATED PELVIC DISEASE

All abnormalities of the pelvic organs encountered during presacral neurectomy should be treated by corrective surgery. In cases of cervical stenosis an adequate dilatation or curettage should be performed. When ovarian tumors or cysts are found, partial oophorectomy and excision of cysts are indicated. Endometriosis is searched for and when found, especially in young individuals, is treated conservatively by cauterization of implants. Retroverted uteri are suspended. The appendix is removed routinely. Phaneuf pointed out that pain *occasioned by mechanical disturbance of the appendix, such as that* accompanying a retrocecal appendix or frequently from an appendix which is adherent to the pelvic organs, may increase at the time of menstruation.

PROCEDURE

Presacral neurectomy is performed most often at this clinic under spinal anesthesia. Dilatation and curettage precede the laparotomy. The patient is then placed in the Trendelenburg position and the abdominal cavity is entered through a lower midline incision extending from the umbilicus to the symphysis. A careful exploration is performed. All pelvic abnormalities are noted and any corrective surgical procedures that are indicated, especially the removal of a large tumor which may interfere with exposure, may be dealt with at this time. The intestine is packed above so that the promontory of the sacrum, the bifurcation of the aorta, and the iliac vessels are well exposed. The sigmoid may be redundant and extend to the midline, in which case it should be mobilized and retracted laterally. If the patient is thin, the presacral nerve may be

seen and palpated beneath the posterior parietal peritoneum. In obese patients, however, it may be hidden in fatty tissue.

The posterior parietal peritoneum is divided in the midline from just above the bifurcation of the aorta down to the level of the bifurcation of the common iliacs (Fig. 331). The peritoneum is separated from the underlying loose con-

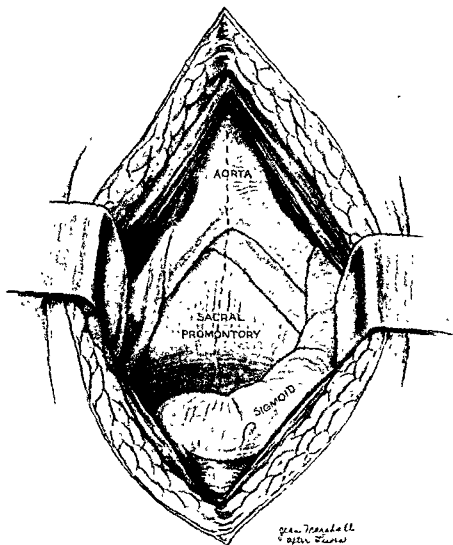


Fig. 331. Incision of posterior peritoneum.

nective tissue and retracted laterally with silk guide sutures. The triangle formed by the bifurcation of the aorta and the common iliac arteries is then well exposed. The left common iliac vein is seen medial to the left common iliac artery. The right common iliac vein is not visualized as it runs lateral to the right common iliac artery outside the field of dissection. The right ureter is usually exposed, the left ureter is rarely exposed. The midsacral artery parallels the presacral nerve and occasionally is divided to facilitate freeing the plexus.

A tape is placed around the plexus and the adjacent closely attached areolar tissue so that the plexus may be lifted from its bed, thus making dissection easier (Fig. 332). The dissection must be meticulous and hemostatic so that all of the fibers of the plexus and the closely adjacent connective tissue are excised, and so that there is no possible chance of injuring the important neighboring structures. The upper aspect of the plexus is freed to about 2 to 3 cm. above the bifurcation of the aorta and is divided and ligated at this level. The dissection is then continued caudad over the left iliac vein to the bifurcation of the common iliacs. It is well to remember that the fibers from the upper ganglions may pass posterior as well as anterior to the iliac vessels.

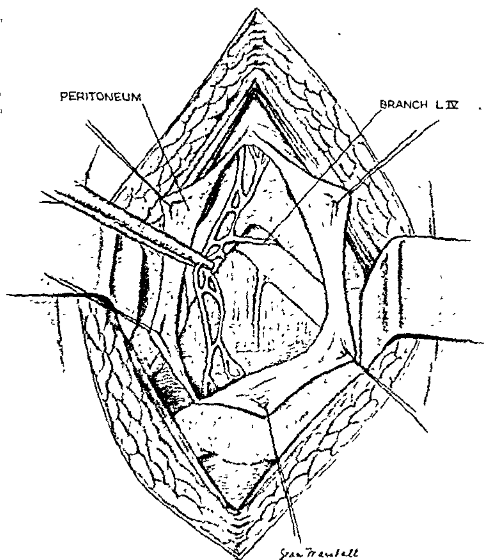


Fig. 332. Exposure of plexus.

As the lower aspects of the plexus are approached it may be found to divide into two more or less distinct branches, the so-called hypogastric nerves. At the

level of the bifurcation of the common iliacs the
distal branches ligated. The field is examined for l
peritoneum closed. If indicated corrective proce
formed earlier, they should be carried out at this t
formed. The abdomen is closed in layers.

The operation is a simple procedure with pra
operative complications are few. Presacral neurect
with the same hazards and complications of any lap
thesia and because of this it should be elected onl
deliberation. By proper selection of cases and comp
plexus, gratifying results may be obtained.

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TREATMENT OF PROLAPSE OF THE UTERUS

BENTLEY P. COLCOCK

Several well-known operative technics have been developed for the treatment of uterine prolapse, each of which has its ardent advocates. In one clinic the great majority of these patients are submitted to vaginal hysterectomy; in another clinic the majority are treated by the Watkins-Wertheim interposition operation and in still another clinic they are, with few exceptions, operated on according to the Manchester-Fothergill technic. In many smaller hospitals the procedure of ventral fixation is still being used for the treatment of this condition.

It is appreciated that any one of these different technics, skillfully carried out by a careful operator, will yield a high percentage of satisfactory results in the treatment of uterine prolapse. Moreover, the enthusiastic adherents of one particular procedure have learned the necessity of modifying it under certain conditions and often, under these conditions, their operation becomes a composite of two or more operative procedures. Nevertheless, it is generally agreed that each of the standard operative procedures used in the treatment of uterine prolapse is particularly adapted to a certain type of prolapse and a particular set of operative conditions In order to secure the highest percentage of satisfactory end results the surgeon treating these patients should have a thorough appreciation of the important variable factors involved in prolapse of the uterus and of the various operative procedures which have been developed to correct these particular aspects of the problem. He should be thoroughly familiar with the indications and contraindications for each of these operative procedures and, above all, he must be willing to vary his preferred technic whenever the operative conditions indicate that another procedure would be preferable. The importance of fitting the operation to the patient rather than fitting the patient to the operation should never be forgotten.

FACTORS INFLUENCING CHOICE OF PROCEDURE

Age, Marital Status and Condition of the Patient. For a young woman in the child-bearing age any operative procedure which may predispose to sterility, to premature delivery or to cervical dystocia should be avoided if possible (that is, procedures such as the Manchester-Fothergill operation which include amputation of the cervix). In middle-aged women the possibility of so shortening the vagina as to produce dyspareunia must be kept in mind (as may occur in vaginal hysterectomy). In the latter instance the marital status of the patient may permit a procedure which one would otherwise hesitate to use In the older age group the problem of child-bearing no longer applies and dyspareunia be-

Revision of article originally published in Surgical Clinics of North America, 29 847–860 (June) 1949.

comes less important. One learns by experience, however, never to disregard entirely the complication of dysparcunia in any patient, regardless of age. Beyond middle age the possibility of malignant disease of the cervix or fundus may influence the choice of operative procedure, and here also the general health of the patient often must be taken into consideration.

Degree of Prolapse. Moderate degrees of prolapse can be well controlled by procedures such as the Manchester-Fothergill operation in which the cervix is amputated and the cardinal ligaments approximated in front of the lower uterine segment. This is particularly true when the major part of the prolapse is due to a markedly elongated cervix. We do not believe, however, that it is reasonable to expect such a procedure to control a complete prolapse in which all, or practically all, of the uterus can be drawn outside the introitus. Nor do we feel that the Watkins-Wertheim interposition procedure is suitable for prolapse of this degree. Here, the fundus may be held up well by its suspension to the tissues along the pubic rami, but unless some additional fixation is used, the lower uterine segment will swing down and prolapse. Vaginal hysterectomy will provide the most satisfactory fixation for this severe degree of prolapse and unless contraindicated by other considerations, is the procedure of choice in these patients.

Degree of Cystocele Present. The size of the cystocele associated with uterine prolapse will vary markedly from patient to patient. There may be little or no cystocele present in the rare nulliparous patient in whom uterine prolapse develops or it may, in other patients, represent the major part of the pelvic descent. If the age of the patient and the size of the uterus do not offer contraindications, few procedures are better adapted to the treatment of a large cystocele associated with moderate prolapse than is the Watkins-Wertheim interposition operation. On the other hand, if the cystocele as well as the prolapse is only moderate and the patient is in the premenopausal age, a procedure of the Manchester-Fothergill type will correct the prolapse just as satisfactorily and will provide a more pliable and better functioning vagina.

Size and Condition of the Uterine Fundus and Cervix. The presence of uterine bleeding, or a Papanicolaou smear suggestive of malignant disease, may make it desirable to remove the uterus in a patient with uterine prolapse. A small uterine fundus is not well adapted to support a large cystocele when the interposition operation is considered. A fibroid uterus of considerable size may make vaginal hysterectomy unduly hazardous and the interposition procedure unsatisfactory.

Presence of Other Pathologic Conditions in the Pelvis. Pelvic adhesions as a result of previous pelvic surgery or from pelvic inflammatory disease should make one hesitate before attempting vaginal hysterectomy or the interposition procedure in the treatment of uterine prolapse. Unless there is a definite indication for removing the fundus or unless the prolapse is of marked degree (not likely), a Manchester-Fothergill procedure is preferable under these circumstances.

Vaginal Prolapse following Hysterectomy. This unfortunate development, which is still occasionally encountered, should occur less frequently as the importance of the proper suspension of the vaginal vault at the time of hys

terectomy becomes better appreciated. On the other hand, if the necessity of carefully suspending the vaginal vault by the cardinal ligaments, uterosacral ligaments and the parametrial tissue surrounding the uterine artery, is not fully appreciated, the trend from supravaginal hysterectomy toward total hysterectomy may well result in an increased incidence of this serious complication.

Careful examination of these patients may reveal that the vaginal prolapse is largely due to a cystocele or rectocele, with a lacerated perineum which was not corrected at the time of the hysterectomy. If the vaginal vault is reasonably well suspended a careful anteroposterior repair may correct the situation. Occasionally, the cystocele and rectocele may be associated with prolapse of an elongated cervical stump. This situation may be corrected satisfactorily by removing most of the cervix and approximating the cardinal ligaments in front of the remaining segment of cervix and utilizing this as a support for the vaginal vault. At other times it will be more satisfactory to interpose the remaining segment of cervix beneath the bladder, as in the Watkins-Wertheim interposition procedure, following amputation of any redundant portion, and using this as the main support of the vaginal vault. When the cervix is small and atrophic, or has been entirely removed along with the uterus, a more serious problem is presented. In the elderly patient in whom the function of the vagina is not important, a partial (Le Fort) or total colpocleisis may be carried out and will usually correct the condition quite satisfactorily. In the younger patients in whom it is important to preserve the function of the vagina, some type of abdominal fixation of the vagina must be carried out. The vaginal vault may be suspended to the anterior abdominal wall by silk sutures (Brady) or by fascial strips if its length is not sufficient to reach the anterior abdominal wall (Ward) or by suspension to the uterosacral ligaments according to the vaginal method described by Miller.

OPERATIVE PROCEDURES

Vaginal Repair with Abdominal Suspension. *Advantages.* This procedure is most frequently used in young women with symptomatic uterine prolapse, cystocele, rectocele and lacerated perineum who desire to have more children. If symptoms are not marked I usually advise these young women to wait until they are past the child-bearing period and then have a definitive repair carried out. Occasionally, these patients may be carried along by the use of a pessary until they have completed their families.

Disadvantages. Cystocele, rectocele and lacerated perineum can be corrected quite satisfactorily but, since nothing is done to the uterus itself from below, dependence must be placed upon the round ligament suspension to correct the prolapse. Suspension by the round ligament from above is never as dependable as when the far more important supporting structures in the base of the broad ligament are used, as in the vaginal operations for uterine prolapse. Ventral fixation of the uterus itself is out of the question since the main purpose of the abdominal part of the procedure is to correct the prolapse and at the same time permit subsequent pregnancy.

Technic. 1. An anterior colporrhaphy is first carried out, approximating the

strong pubocervical fascia beneath the bladder from the urethra to the cervix (Fig. 333).

If stress incontinence is present, particular attention must be given at the time of the vaginal repair to correction of the urethrocele and to approximation of the musculofascial tissues about the bladder neck.

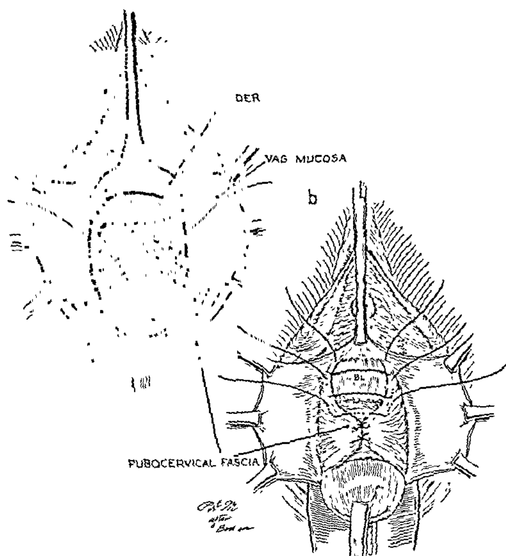


Fig. 333. *a*, Inverted T incision has been made in the anterior vaginal mucosa and the mucosa reflected on each side, carrying it up to within 1 cm. of the urethral orifice. A small transverse incision has been made on each side at the upper end of this T incision to prevent tearing into the urethral orifice. The bladder has been mobilized from the anterior surface of the cervix and uterus.

b, Pubocervical fascia is approximated by mattress sutures beneath the bladder and the urethra. If the patient has urinary incontinence, particular care must be given to approximation of the fascia beneath the urethra and the bladder neck.

2. Careful approximation of the levator ani muscles and repair of the perineum are essential parts of any operative procedure for uterine prolapse (Fig. 334), and it is important to emphasize that this vaginal part of the procedure should be carefully carried out if a satisfactory result is to be obtained by this combined procedure.

3. As in all operations for prolapse, one must make certain that an enterocele is not present. If an enterocele is present and is not corrected it may necessitate reoperation in spite of an otherwise excellent vaginal repair. If it is present the sac should be dissected free and amputated as in any other type of hernia repair. The defect is then closed by approximation of the uterosacral ligaments behind the cervix. The closure of the defect can be reinforced by plicating sutures above when the suspension part of the procedure is carried out.

4. My preference for the round ligament suspension part of the operation is the use of a modified Gilliam suspension in which the round ligaments are

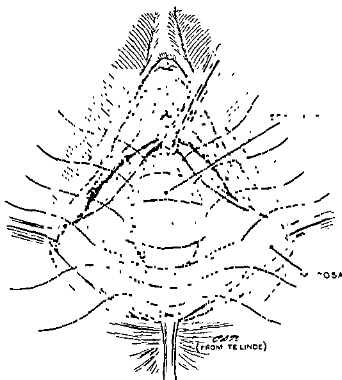


Fig 334 A transverse incision has been made at the mucocutaneous border and the vaginal mucosa of the posterior vaginal wall elevated. If a rectocele is present, as shown, it is reduced

restore the normal contour of the vagina and avoid the production of a ridge, either up in the vagina at the height of the repair or at the fourchet (dashboard perineum).

withdrawn through the internal inguinal ring on each side and brought out over the rectus muscle to be sutured to the undersurface of the rectus fascia. The point of emergence of the round ligaments at the internal inguinal ring should be checked to make certain that no aperture remains through which small bowel might prolapse. Shortening of the uterosacral ligaments will also help to maintain the uterus at the proper level.

The Manchester-Fothergill Procedure. *Advantages.* This is one of the most widely applicable operative procedures for the correction of uterine prolapse. It is not incompatible with pregnancy and normal delivery although the incidence of sterility, premature delivery and cervical dystocia is somewhat increased following its performance. It does not shorten the vagina and, if properly carried out, does not produce dyspareunia The peritoneal cavity is not

lapse of the uterus. When the prolapse is associated with third degree retroversion it is usually not possible to correct the retroversion by this operation.

Technic. 1. Following dilatation and curettage, an inverted T-shaped incision is made in the mucosa of the anterior vaginal wall. The mucosa is reflected, the bladder mobilized up from the cervix, and approximation of the pubocervical fascia beneath the bladder carried out by interrupted mattress sutures of fine chromic catgut. If there is a history of stress incontinence, care must be directed particularly to the urethral floor and the bladder neck.

2. The mucosa is then reflected from the posterior surface of the cervix, the cervix is amputated and the base of each ligament as it inserts into the lower uterine segment is clamped, divided and ligated (Fig. 335, *a*).

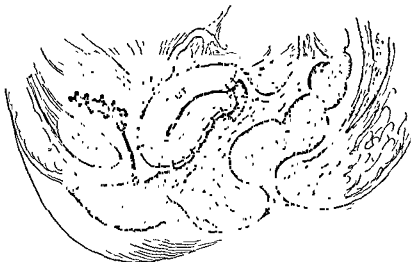


Fig. 336. Watkins-Wertheim interposition operation. The uterus has been delivered and [illegible] The bladder now rests upon the an- [illegible] *provides* [illegible]

3. This fibromuscular tissue (cardinal ligament) is then approximated anterior to the new cervix above the line of amputation (Fig. 335, *b*). This is the essential point in this operative procedure and this strong fibromuscular tissue can be approximated as far as is necessary to raise the new cervix well up in the pelvis and thus provide a high firm support for the vaginal vault. The operation is completed by approximating the anterior vaginal mucosa, repair of the rectocele, if present, and finally, repair of the perineum.

Watkins-Wertheim Interposition Operation. *Advantages.* If the patient has a large cystocele, a moderate degree of uterine prolapse and a normal-sized uterus, the interposition of the uterine fundus beneath the bladder will provide as secure a support for the cystocele as can be found (Fig. 336). Although the peritoneal cavity is opened, this procedure does not involve extensive dissection and can be carried out with a minimum of operative risk. Any existing disease of the cervix can be eliminated by adding cervical amputation, and this also permits a higher support of the lower uterine segments.

Disadvantages. The Watkins-Wertheim interposition operation is incompatible with pregnancy and if carried out in the child-bearing age the fallopian

tubes must be ligated. Because of the firm, unyielding anterior vaginal wall, dyspareunia is a complication which must be considered in young or middle-aged women. If the degree of prolapse is marked, suspension of the uterine fundus beneath the rami of the pubis does not control prolapse of the lower uterine segment and cervix. If cervical amputation is added, the procedure will correct second degree prolapse but complete prolapse is still, in our opinion, better treated by vaginal hysterectomy. If the uterine fundus is small and atrophic it

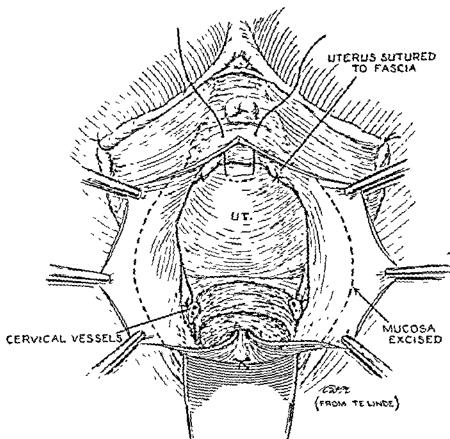


Fig 337. The cervical branches of the uterine artery have been divided and ligated. The cervix has been amputated and the mucosa approximated to the uterine canal in the posterior midline. The cornu of the uterus has been sutured to the fascia along the pubic rami on each side and the mucosa of the anterior vaginal wall will now be approximated in the midline to the uterus after excision of the redundant portion.

does not offer a satisfactory support for the bladder. If the fundus is the seat of a small uterine fibroid, it may not be possible to interpose it beneath the bladder and preserve a satisfactory vagina. If subsequent uterine bleeding occurs, the fundus is in a difficult position to curet satisfactorily in order to rule out the presence of endometrial carcinoma.

Technic. 1. Following dilatation and curettage, the mucosa of the anterior vaginal wall is reflected, the bladder mobilized and advanced from the cervix to a point where the vesical uterine fold is encountered and the peritoneal cavity opened. The bladder must be completely mobilized so that it will rest freely on the posterior surface of the uterus which is to be interposed beneath it. The dysuria and other urinary symptoms which have been reported following the

employment of this procedure are probably due to an inadequately mobilized bladder, the floor of which is pushed up by the interposed uterine fundus.

2. The adnexa are then carefully palpated to rule out adnexal disease and the presence of any intra-abdominal fixation of the fundus. The size of the uterus can also be determined at this point, and it can be determined whether it can be brought beneath the bladder to form a satisfactory support.

3. The cervix is then amputated following ligation of the cervical branches of the uterine arteries and the posterior vaginal mucosa approximated to the cervical canal by a Sturmdorf suture.

4. The uterine fundus is then delivered through the opening in the vesicouterine fold of peritoneum. This can be done either by a tenaculum or by successive figure-of-eight sutures in the anterior wall of the uterus. Each cornu is then securely sutured to the firm fibromuscular suture along the lower border of each ramus of the pubis. The mucosa is approximated over the fundus of the uterus and the anterior portion of the cervix and repair of the perineum is carried out (Fig. 337).

Vaginal Hysterectomy. *Advantages.* Vaginal hysterectomy is, in our opinion, the most satisfactory method of treating the patient of 60 years of age or over who has severe or complete prolapse of the uterus. Although it involves more dissection than either the Manchester procedure or the interposition operation, it still can be carried out with a low operative risk, even in elderly women. The utilization of all the supporting structures contained in the broad ligaments, as well as the uterosacral ligaments, insures a secure, adequate support to the vaginal vault. If necessary, these broad ligaments can be approximated to form a sling and fixed to the pubic rami beneath the bladder. The fundus as well as the cervix is eliminated, which is advantageous in this group of patients who all fall in the cancer age group.

Disadvantages. When we employ vaginal hysterectomy for the correction of uterine prolapse, utilizing the approximated broad ligaments for suspension of the apex of the vaginal vault, there is likely to be appreciable shortening of the vagina. For this reason we do not feel that it is the procedure of choice in patients in whom the function of the vagina is important unless the prolapse is complete. Pelvic adhesions, as a result of either previous surgery or pelvic inflammatory disease, may make delivery of the uterus from below unduly hazardous. If this complication is encountered unexpectedly after opening the peritoneum from below, it is wise to carry out the repair of the cystocele, rectocele and perineum from below and complete the hysterectomy from the abdominal approach or else abandon the proposed vaginal hysterectomy in favor of another vaginal method of treating the uterine prolapse.

Technic. 1. Patients with complete prolapse usually have considerable edema, vascular congestion and often ulceration of the exposed vaginal mucosa. These patients should be kept in the hospital twenty-four to forty-eight hours before operation to help relieve this congestion and prepare the operative field in so far as is possible.

2. Dilatation and curettage is carried out to rule out malignancy of the fundus for, if malignancy of the fundus is found, we prefer to carry out an abdominal

hysterectomy, removing the adnexal and parametrial tissues more completely than can be done by vaginal hysterectomy. The mucosa is reflected from the anterior surface of the uterus, the bladder freed and the peritoneal reflection exposed. The peritoneal cavity is opened at this point as in the interposition procedure, following which the mucosa is reflected from the posterior surface of the cervix and the peritoneum opened in the posterior cul-de-sac. The fundus is delivered through the anterior opening and both cervix and fundus drawn to the patient's right side. This permits palpation and visualization of the entire left broad ligament. The broad ligament is then ligated by successive mattress sutures and its attachments to the uterus and cervix divided. Since we are not

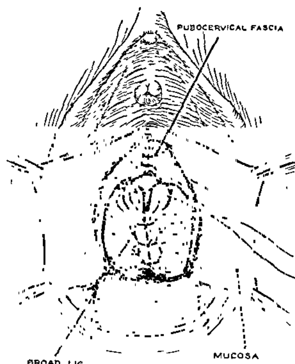


Fig 338. Vaginal hysterectomy. The uterus has been removed. The anterior and posterior peritoneal flaps have been approximated and now the ligated broad ligaments on each side are approximated in the midline to form an extraperitoneal sling which will support the vagina.

operating for removal of malignant disease the division can be carried out very close to the uterus and thus avoid the risk of injuring the ureters.

3. With the partially liberated uterus retracted in the opposite direction, the right broad ligament is ligated and divided in a similar manner and the uterus and cervix removed.

4. The tubes and ovaries are then inspected and removed if necessary.

5. The peritoneal cavity is closed by suturing the anterior and posterior margins of the peritoneum, thus creating a smooth peritoneal floor with the ligated broad ligaments becoming *extraperitoneal at each end of the closure* (Fig. 338).

6. The cervical fascia is approximated beneath the urethra and bladder and the exposed end of the broad ligaments approximated in the midline beneath the new peritoneal floor.

7. The anterior border of each broad ligament may then be sutured to the

fascia underlying the pubic rami, thus interposing the broad ligament sling beneath the bladder and urethra. The anterior vaginal mucosa is closed, utilizing the broad ligament sling as a support to the anterior wall and the vaginal vault.

8. The posterior vaginal mucosa is raised, carrying the dissection almost to the height of the anterior dissection.

9. The levator ani muscles are then visualized and approximated as high as possible, the height of the approximation being governed by the need of that particular patient for preserving a functioning vagina. The transverse perineal muscles of the perineum are then built up to form additional support for the anterior wall.

10. A sponge is placed in the vagina for hemostasis, and an indwelling catheter is left in the bladder as in all other vaginal plastic procedures.



Fig. 339. The vaginal mucosa has been reflected from the underlying fascia both anteriorly and posteriorly. This prolapse of the vagina is then inverted by successive purse-string sutures until it is entirely replaced. The excess mucosa is excised, leaving just enough to cover the last inverting suture.

Total Colpocleisis. *Advantages.* This procedure will correct prolapse of the vaginal vault with associated prolapse of the bladder and rectum, following supravaginal or total hysterectomy. It can usually be carried out without undue operative risk, even in elderly patients.

Disadvantages. The importance of complete loss of vaginal function will vary according to the age, marital status and personality of the patient.

Technic. In total colpocleisis the entire vaginal mucosa from the anterior and posterior walls is removed and the vaginal vault inverted by successive purse-string sutures (Fig. 339), or successive rows of interrupted sutures approximating the anterior and posterior submucosal fascial structures. The small margin of the mucosa at the introitus is then approximated with a few interrupted sutures.

Combined Procedures. As has been pointed out before, salient features of one or more of the previously mentioned procedures may be combined to

fit a particular need in a particular patient. We have had no experience with the Spalding-Richardson composite operation as described by Te Linde but the underlying principles are sound and it should give excellent results when indicated. It eliminates both the fundus and the cervix as a source of future trouble for the patient and at the same time preserves the lower uterine segment with its undisturbed important adjacent fascial structures to form the support for the vaginal vault.

SUMMARY

Based on the factors mentioned, the operative technic used is that which best satisfies the needs of the particular patient in question. In general, if the patient is a young woman in the child-bearing period in whom operative intervention is necessary because of the severity of symptoms, we usually carry out a careful anterior and posterior colporrhaphy supplemented by suspension of the round ligaments. In the usual patient who is between 45 and 60 years of age and who has cystocele, rectocele and uterine prolapse of first or second degree, we prefer to perform a Manchester-Fothergill type of procedure, including amputation of the cervix and plication of the cardinal ligaments. In the patient with third degree or complete prolapse of the uterus, we usually carry out a vaginal hysterectomy, approximating the broad ligaments and fixing the vaginal vault to the broad ligament sling. The surgeon, however, must be prepared to change his proposed operative procedure even after the operation has begun if specific contraindications are present or conditions encountered which suggest that another type of technic would provide a more satisfactory repair.

CONCLUSIONS

As has been pointed out before, a well chosen technic carried out with a minimum of trauma to the patient, with careful dissection and accurate approximation of tissue and the use of fine suture material, will pay high dividends in grateful, comfortable patients and should result in a minimum of recurrences in uterine prolapse.

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TOTAL COLPOCLEISIS FOR PELVIC EVENTRATION

HERBERT D. ADAMS

Prolapse of the vagina or cervical stump following total or supravaginal hysterectomy is a most incapacitating and distressing condition. These unhappy and greatly restricted patients are in great need of a satisfactory and dependable operative procedure to rehabilitate them. When I was first confronted with this problem some 15 years ago, it became apparent that there was no specific operative procedure that was entirely adequate for the relief of this distressing situation. The criteria for a completely satisfactory operation for this condition demanded: first, complete relief of the associated incapacitating symptoms, and, second, permanency of the support and nonrecurrence of any degree of the prolapse.

Standard types of repair, repair with abdominal suspension of the vagina or cervical stump, or the Le Fort's operation have not fulfilled these criteria. Because of dissatisfaction with the results of these procedures, I developed a totally obliterating vaginal operation termed total colpocleisis. The first patient in this series was operated upon in 1937. Since that time I have used this procedure in 30 cases. As experience increased it became apparent that this operation was also indicated in patients with extreme degrees of uterine prolapse associated with huge enteroceles (or cul-de-sac hernia) and complete loss of support. In this series there were 11 of this latter type of case.

The single disadvantage of this operation is the permanent and complete obliteration of the vagina and the loss of the marital function of the vagina. Actually this has not proved to be a point of importance in this series. In most of these patients, because of their age and the long-standing severe degree of the prolapse, this loss of marital function was of no importance to them, and even in the few cases in the younger age group, these patients were so miserable and confined by their symptoms that both the patient and her husband, even after careful explanation of the procedure, were more than willing that the operation be performed provided permanent relief of these symptoms could be promised. With this procedure it has been possible to assure them of an excellent and permanent result and, without exception, these patients have been completely relieved of their distressing, incapacitating symptoms and have been exceedingly grateful and satisfied with the result.

Because of the extent and duration of the prolapse in these patients, they should be prepared for forty-eight hours in the hospital, chiefly to give the patient some needed rest and reduce the local congestion of the tissues to facilitate operation and reduce blood loss. This time should also be utilized for a careful

Originally published in Surgery, Gynecology and Obstetrics, 92 321–324 (Mar.) 1951.

soap and water preparation of the prolapsed mucosal tissues and to prepare the lower bowel by catharsis, enemas, and a low residue diet.

TECHNIC OF OPERATION

The operation itself is carried out under spinal pontocaine anesthesia with the patient in the usual lithotomy position. The bladder is emptied and the entire perineal region carefully prepared with ether and zephiran. If the cervix is present it is grasped with a tenaculum, or if a total hysterectomy has

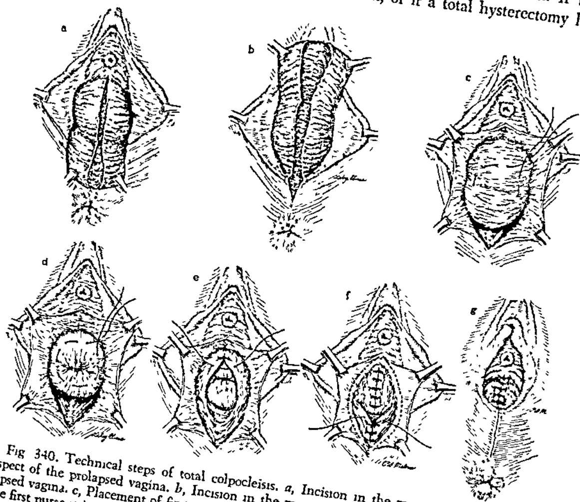


Fig 340. Technical steps of total colpocleisis. *a*, Incision in the mucosa of the anterior aspect of the prolapsed vagina. *b*, Incision in the mucosa of the posterior aspect of the prolapsed vagina. *c*, Placement of first purse-string suture about the apical vaginal scar. *d*, Using the first purse-string suture as a focal point, a series of purse-string sutures is placed to invert the bladder and the rectum and reduce the prolapse. *e*, Plication of the pelvic fascia. *f*, Plication of the levator and transverse perineal muscles to obliterate the vagina. *g*, Completed operation after closure of mucosa.

been done, the scar representing the apex of the vagina is identified and is likewise grasped with a tenaculum. The mucosa on the anterior aspect of the completely prolapsed vagina, which on this aspect represents an almost complete eventration of the bladder, is opened (Fig. 340, *a*) from the cervix or vaginal apical scar to a point just below the urethra. These mucosal flaps are elevated from the bladder and the walls of the vagina laterally as far as the labial margin. The controlling tenaculum is then elevated, exposing the posterior aspect of the prolapsed vagina which represents an eventration of the rectum or, in

Table 1. Summary of Clinical Data in 30 Cases

CASE	AGE, YEARS	MARITAL STATE	DATE OF PREVIOUS OPERATION	TYPE OF PREVIOUS OPERATION	SYMPTOMS	DURATION, YEARS	DATE OF COLPOCLEISIS	COMPLICATIONS	RESULT
1	54	M	1918	Supravaginal hysterectomy	Prolapse, frequency	10	12– 3–37	None	Excellent
2	68	W	1915	Supravaginal hysterectomy	Prolapse, frequency, dysuria	23	3– 2–38	None	Excellent
3	63	D	1906	Supravaginal hysterectomy	Prolapse	34	6– 3–40	None	Excellent
			1924	Suspension					
4	53	W	1935	Total hysterectomy	Prolapse, pain	5	9– 5–40	None	Excellent
5	57	M	1939	Supravaginal hysterectomy	Prolapse, pain, bleeding	1	10–22–40	None	Excellent
6	71	W	1921	Supravaginal hysterectomy	Prolapse, vaginal bleeding	20	5–31–41	None	Excellent
			1940	Le Fort's operation					
7	65	W*			Prolapse, frequency, incontinence (enterocele)		6–26–41†	None	Excellent
8	65	M	1921	Supravaginal hysterectomy	Prolapse, dysuria, frequency	12	9– 4–41	None	Excellent
9	45	M	1935	Total hysterectomy	Prolapse, pain, dysuria, frequency	6	9– 8–41	None	Excellent
10	71	W	1937	Total hysterectomy	Prolapse, pain, frequency	4	10–15–41	None	Excellent
11	59	S	1934	Vaginal hysterectomy	Prolapse, dysuria, frequency	1	12–10–41	None	Excellent
12	75	W	1936	Total hysterectomy	Prolapse, pain bladder and rectum	6	3–19–42	None	Excellent
13	72	W	1921	Panhysterectomy	Prolapse, stress, incontinence	10	4–29–43	None	Excellent
14	64	M	1925	Panhysterectomy	Pain, dysuria, frequency		4–18–45	None	Excellent
15	72	M*			Prolapse, pain, frequency, bleeding (enterocele)	8	7–11–45†	None	Excellent
16	60	M	1931	Panhysterectomy	Prolapse, bloody discharge	6	7–24–45	None	Excellent
17	63	M	1906	Repair	Prolapse, pain, frequency, incontinence (enterocele)	10	5–31–46†	None	Excellent
			1916	Repair					
			1934	Repair					
18	70	W	1945	Vaginal hysterectomy	Prolapse, pain (enterocele)	1	7– 6–46	None	Excellent

19	71	W*	1908	Suspension	Prolapse, pain, discharge	5	9–11–46†	None	Excellent
20	51	M	1942	Panhysterectomy	Prolapse, pain	2	12–18–46	None	Excellent
21	76	W	1912	Pelvic operation	Prolapse, stress, incontinence	20	1– 6–47†	? Cardiac infarction	Excellent
22	58	W*			Prolapse, frequency (enterocele)	10	2–19–47†	None	Excellent
23	62	W	1943	Panhysterectomy	Prolapse, pain	25	9–26–47	None (history of "milk leg," bilat., superior femoral venous ligation at operation	Excellent
24	59	M	1935	Total hysterectomy	Prolapse, pain, frequency, incontinence	12	10– 3–47	None	Excellent
25	62	Separated*			Prolapse, urinary frequency (enterocele)	4	9–21–48†	None	Excellent
26	62	M*			Prolapse, pain, frequency, bleeding (enterocele)	14	10–21–48†	Thrombophlebitis, diabetes	Excellent
27	65	M*			Prolapse (enterocele)	6	12–30–49†	None	Excellent
28	54	M*	1933 1949	Suspension Repair	Prolapse (enterocele)	1	2–15–50†	None	Excellent
29	59	W	1941	Supravaginal hysterectomy	Prolapse	1	4–29–50	None	Excellent
30	69	M*			Prolapse, frequency, dysuria	3	7–26–50†	None	Excellent

* No previous hysterectomy but patient had uterine prolapse and enterocele
† Vaginal hysterectomy plus colpocleisis

many instances, a large enterocele. The posterior fourchet is grasped with double hooks on either side of the perineum, the mucosa excised transversely at the mucocutaneous border of the perineum, and the posterior mucosa elevated as in a standard perineorrhaphy. The mucosa is then incised in the midline to encircle the cervix or vaginal apical scar and to connect with the anterior mucosal incision. This forms two mucosal flaps resulting from a midline incision extending from the perineum (Fig. 340, *b*) to the urethra and elevated laterally from the sides of the bladder, rectum, and the vaginal walls, being freed laterally as far as the mucocutaneous borders of the vagina. The cervical stump if present is then amputated as high as possible and, using the apical vaginal scar as a focal point, a series of purse-string sutures is placed (Fig. 340, *c* and *d*) to invert progressively the bladder and rectum and thereby reduce the prolapse. This likewise brings the bladder and rectum back to a normal relationship in the pelvis when viewed in a sagittal section.

The urethra is then plicated. The pelvic fascia, the levator and transverse perineal muscles are brought together (Fig. 340, *e* and *f*) to obliterate the vagina completely, the levator muscles and fascia being plicated beneath the urethra to construct a solid, strong, permanent support for the bladder and rectum.

The excess of the lateral vaginal mucosal flaps is removed and the mucosa closed (Fig. 340, *g*) leaving only a vestige of the vagina—a small (2 cm.) dimple just below the urethra to provide an unobstructed flow of the urinary stream from the urethral orifice. The perineal skin is closed with a fine subcuticular suture.

OTHER PROCEDURES

A modification of this procedure has been utilized effectively in patients with complete procidentia associated with huge enteroceles. This marked degree of

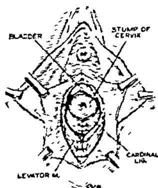


Fig. 341. Plication of the cardinal ligaments *behind* the cervix rather than anterior to it for the control of enterocele.

herniation of the cul-de-sac has also been extremely difficult to cure by standard procedures. In those patients with a lesser degree of prolapse but who have an associated marked enterocele, I have used a modified Manchester-Fothergill procedure, amputating the cervix and plicating the cardinal ligaments *behind* the amputated cervical stump (Fig. 341), rather than anterior to it as in the standard procedure, in order to prevent recurrence of the cul-de-sac hernia.

The cases with the marked degrees of procidentia associated with huge enteroceles are, however, best managed by vaginal hysterectomy, plication of the cardinal and broad ligaments and total colpocleisis.

CONCLUSION

It is evident that with these specific indications and careful selection of cases for total colpocleisis there will not be a large number of patients in whom this procedure should be used. In my own experience, in a period of 15 years it has been used in 30 cases. Table 1 shows the clinical data of this series of patients. It will be noted that the ages range from 45 to 75 years. Many of these patients had had previous attempts at repair, including standard types of colporrhaphies, abdominal suspension of the stump, Le Fort's operation, but with recurrence and progression to the extreme degrees of distressing prolapse. It is also apparent that, since the incidence of total prolapse of the vagina and its related organs after hysterectomy is not great, this would indicate that the majority of surgeons and gynecologists are exercising care in the technical details of suspension of the cervical stump or vagina after hysterectomy. The fact that this distressing condition still occurs, however infrequently, justifies a plea and calls specific attention to the importance of these details of suspension during hysterectomy. Since all these patients were operated on without a serious complication or mortality, all have obtained excellent permanent results and over half have been followed for five years and others considerably longer, these excellent results have completely justified the application of this procedure in this selected group.

COMPLICATIONS OF TRANSURETHRAL PROSTATIC RESECTION

VERNON S. DICK, EARL E. EWERT AND LLOYD D. FLINT

Transurethral prostatic resection has been the method of treatment used at the Lahey Clinic for 85 to 90 per cent of patients who have vesical neck obstruction. The results, generally speaking, have been most satisfactory, and we plan to continue doing transurethral resections. The purpose of this review of the complications of the operation is not to detract from its merits but rather once again to call attention to the dangers inherently present in this type of surgical procedure and to emphasize measures that can be taken to minimize further the morbidity and mortality of the procedure.

The basis of the statistics is a review of the unselected records of 500 patients who underwent transurethral prostatic resection sufficiently long ago that complications directly related to the operation could be evaluated, but operated on recently enough that many of the advances in chemotherapy had been utilized in their management. These cases include both benign and malignant prostatic obstruction in the proportion of 92.4 per cent benign to 7.6 per cent malignant. The low incidence of malignant disease in this series of resections may be due to the fact that many advanced carcinomas were not resected if they responded favorably to hormonal therapy, and in the early cases open perineal operation was performed. The ages of the patients ranged from 26 to 86 years.

The operation, performed by several different surgeons, was done with the Nesbit modification of the Stern-McCarthy resectoscope, using a number 28 French sheath in all but a few cases, in which the 24 French Stern-McCarthy instrument was employed. Sterile distilled water was the irrigating fluid. Immediately preceding the resection, bilateral vasectomy was done in the operating room in 53 per cent of the patients, the urethra was calibrated and meatotomy or external urethrotomy performed if indicated. The plan of resection followed in general that described by Nesbit, with amounts of tissue removed varying from 2 gm. to 143 gm. Efforts were made to obtain complete hemostasis before the patient was permitted to leave the operating room A number 24 French Foley catheter with a 30 cc. bag was the drainage usually employed, this catheter was ordinarily removed on the third postoperative day The average postoperative stay in the hospital was eleven and a half days. Follow-up examinations were made approximately three to four weeks after discharge, and as often thereafter as indicated.

COMPLICATIONS DURING THE IMMEDIATE POSTOPERATIVE PERIOD

Hemorrhage. Excessive bleeding with clot formation and interference with drainage through the catheter occurred in 5 per cent of the patients reviewed.

Originally published in Surgical Clinics of North America, 30:935–940 (June) 1950.

In one patient this was the direct cause of death; severe bleeding developed quickly on the night of operation, and shock and cardiac failure occurred before effective counter measures could be used. In most of these patients, however, prompt return to the operating room with transurethral evacuation of clots and fulguration of bleeding vessels under either spinal or intravenous pentothal anesthesia improved the situation so that further convalescence was uneventful. Two patients required suprapubic cystotomy and packing of the prostatic bed. One of these had a large capsular vessel exposed in the anterior portion of the fossa, and the other had a large artery on the floor near the apex in such a position that it was thought fulguration might cause damage to the rectal wall. Late bleeding which usually occurred in the first week or ten days after discharge from the hospital developed in 2.2 per cent, requiring the patient's return to the hospital for replacement of the catheter and hemostasis.

Rupture of Prostatic Capsule or Vesical Neck. Urinary extravasation due to perforation of the prostatic capsule or elevation of the trigone occurred in 0.8 per cent. Prompt recognition of the condition with suprapubic drainage saved 2 of these 4 patients. One patient died ten days after operation despite prompt drainage and in the other case extravasation was not immediately recognized, open drainage was deferred until the thirteenth day and the patient died on the following day in uremia and shock. There was no evidence of hemolysis in either of these patients, but severe shock characterized both. Whether the fact that distilled water was used as the irrigating fluid influenced the outcome of these accidents of surgical technic cannot be determined definitely, but it seems unlikely.

Postoperative Difficulty in Voiding Requiring Re-resection. Sufficient difficulty in voiding was noted in 2.2 per cent of the patients during their immediate postoperative period to require return to the operating room for endoscopy and additional resection of prostatic tissue. Almost half of the patients with this complication had a neurogenic element in their obstruction, and in 1 case a two-stage procedure was deliberately planned. We have tried to select patients for transurethral resection so that a thorough prostatic removal can be done in one hour of operating time. An occasional error in judging the size of the gland, excessive bleeding, small bladder capacity and instrumental difficulties sometimes upset this plan and re-resection became necessary.

Sepsis. In 4 per cent, severe infection with temperatures over 102° F. for two days or more occurred following operation. In none of these patients was the infection really serious in that no lasting injury was produced, and sulfonamides and various antibiotics quickly brought the majority of these infections under control. Our impression is that the most severe febrile responses occurred in those patients who had previously not had an infection of the urinary tract.

Epididymitis. It is interesting that epididymitis occurred in only 2 patients (0.4 per cent) while in the hospital, but developed in 3.4 per cent within a short time after discharge. Three patients in whom epididymitis developed while at home had had a bilateral vasectomy. Vasectomy was done at the time of the transurethral operation in 53 per cent of the entire group. It would appear that the chemotherapy which most of these patients received while in the hos-

pital helped prevent this particular complication during that period, but epididymal infections developed in some patients when they no longer had that protection.

Partial Incontinence. In 2 patients, or 0.4 per cent, partial incontinence was present from the time of removal of the catheter, and persisted as long as the patient's course was followed. Both these patients had neurogenic bladders. This complication was not seen in a permanent form in any of the other cases. However, 4 per cent had a slight stress incontinence for the first few months.

Nonurologic Complications. In 4.4 per cent of the series studied, some complications developed postoperatively which did not directly involve the urinary tract. These included an acute attack of gout, myocardial infarction, cerebral hemorrhage, phlebothrombosis, sulfonamide reactions, pulmonary emboli, transfusion reaction, pneumonia, acute gangrenous cholecystitis and atelectasis.

Rupture of the bladder due to explosion of gases accumulating in the bladder did not occur either in this series or in any other patient under our observation. Likewise, there were no instances of damage to the rectum, of periurethral or periprostatic abscess or demonstrable hemoglobinemia.

MORTALITY

The operative mortality was 1.8 per cent, there being 9 deaths in this series of 500 patients. One patient died of severe shock associated with sudden bleeding the night of operation, 2 other patients died of uremia and shock associated with urinary extravasation, a fourth died of coronary thrombosis on the tenth postoperative day, the fifth died as a result of a mismatched transfusion, and 2 died of sudden cerebral hemorrhage. The remaining 2 patients succumbed to a combination of congestive heart failure, nephrosclerosis and uremia; one of these patients had widespread metastases from carcinoma of the prostate.

COMPLICATIONS DURING THE LATER POSTOPERATIVE PERIOD

Urethral Stricture. In this series the most frequent and most annoying complication which appeared during the first few weeks or months following discharge from the hospital was urethral stricture. Some degree of urethral narrowing developed in 15.8 per cent, although admittedly in some of these cases the narrowing was minor and very easily handled. Thirteen per cent had meatal or navicular strictures, 1.6 per cent had penoscrotal strictures and 0.6 per cent had strictures elsewhere in the urethra. Of the group of patients in whom meatal strictures developed, 27 per cent underwent meatotomy as an office procedure, and in the remainder the strictures were handled by simple dilatations. Meatotomy was done in 7 per cent and external urethrotomy was carried out in 6.2 per cent at the time of operation. In view of this incidence of stricture it appears that urethrotomy should have been carried out in a much larger percentage.

Persistent Infection. At least 8 per cent of the patients studied had a urinary infection which lasted more than three months following the transurethral operation. Many of these had some complicating conditions of the urinary tract such as calculi, diverticula, neurogenic bladder, hydronephrosis, hydroureters and chronic pyelonephritis. The policy of making preoperative

intravenous urograms whenever possible has been helpful in anticipating persistent infection due to such causes. Our information on the duration of urinary infection is not entirely accurate since some patients failed to return for the later re-examinations, but the records definitely indicate that no large number had persistent pyuria resulting solely from the operation.

Late Bleeding. As stated in the discussion of hemorrhage, in 2.2 per cent of the patients sufficient bleeding developed after discharge from the hospital to require their return for hemostasis or at least the insertion of an indwelling catheter. The hospital stay of these patients, however, was very short. An unknown number of patients had slight bleeding for the first three weeks after discharge from the hospital, but required no surgical treatment.

Recurrent Obstruction. Our data regarding recurrent obstruction are entirely inadequate but it is known that 12 or 2.4 per cent of these 500 patients have returned to the clinic for additional resections after periods varying from three months to thirteen years. Five of these patients had recurrent carcinoma.

Other Late Complications. As previously stated, 4 per cent of the patients had slight stress incontinence for the first few months.

Only 2 patients had persistent partial incontinence, and both had neurogenic bladders. Three patients complained of sexual difficulty consisting of lack of ejaculation and 2 patients were very concerned about the loss of potency. Undoubtedly others had such symptoms but accurate information on development of sexual difficulties following transurethral resection was not obtainable from our records.

In 1 of the patients whose vesical neck was perforated and who required immediate suprapubic drainage a syndrome developed later which resembled osteitis pubis. He was incapacitated for some weeks by pain over the suprapubic region, inner thighs and perineum, all aggravated by motion of the hips. Roentgenograms were repeatedly negative for bone disease but clinically osteitis pubis was strongly suggested. Complete recovery occurred eventually.

COMMENT

From this review it would seem that the most frequent immediate complication of transurethral prostatic surgery is hemorrhage, with rupture and extravasation the most serious in regard to early mortality. In the prevention of hemorrhage, thorough resection with careful, accurate fulguration of bleeding vessels, prompt replacement of blood loss by transfusion and vigilant care especially during the first twenty-four hours are necessary. Within reason, the frequency of irrigation of the catheter or type of fluid used is not a factor in either promoting or preventing bleeding. Return to the operating room for transurethral hemostasis without waiting until serious difficulty is present is the best procedure for any patient whose bleeding is at all excessive. As to hemorrhage occurring after discharge from the hospital, the performance of as complete a removal of the prostate as possible, minimizing infection and warning the patient to avoid straining, lifting and the like for the first few weeks help to keep this complication at a low rate.

Perforation of the prostatic capsule and vesical neck can be prevented only by caution at all times but particularly when cutting at the bladder neck, espe-

cially anterolaterally where it is impossible to feel the thickness of tissue. Complete orientation and visualization of the procedure in three dimensions must be obtained. The ruptures that occurred in our patients were associated with bleeding that was not well controlled and resultant momentary loss of orientation. If perforation is seriously suspected it is better to stop the operation and carry out suprapubic drainage immediately than to worry along perhaps allowing more irrigating fluid and urine to extravasate and finally be forced to operate later when the patient's condition is poor.

In regard to epididymitis we still believe that despite the fact that only 19 patients (3.8 per cent) developed this complication, prophylactic bilateral vasectomy at operation is worth while, especially in patients in the older age group, in unusually feeble patients and in those who come from regions where later medical attention may not be easily obtained. It often seemed to be the patient who could tolerate epididymitis least well who developed it. Vasectomy adds but a few minutes to the operating time and only 4 of 265 patients who had vasectomy developed any complication of the procedure itself, all hematomas. None required operative treatment.

As to the operative mortality, of the 9 deaths in this series 4 apparently could have been prevented. The transfusion accident, however, was beyond the direct control of the surgeon, but the death from hemorrhage and the 2 fatalities resulting from rupture might well have been avoided. The other 5 deaths were in men known to have had serious cardiovascular disease and the risks of any type of treatment had to be assumed; the surgical procedure itself in these cases appeared to be uncomplicated.

The incidence of urethral strictures in this series is definitely higher than we like and calls for greater care and judgment in the handling of the urethra. It is our practice to do a short, perineal urethrotomy whenever there is the least snugness on a number 30 French steel sound, if the suspensory ligament is unusually short or if the gland is very high. Some patients, however, appear to have a sufficiently large urethra at the start of the resection, but as one proceeds with the operation, a tightening of the urethra becomes apparent. There is a tendency to continue with the resection, particularly if the gland is not very large, rather than to stop, do a meatotomy or urethrotomy or at least relubricate the urethra. It is probably failure to heed the warning of this tightening that has resulted in some postoperative strictures. Fortunately, most of these were easily handled by simple dilatation or meatotomy but when stricture occurred in patients living at a distance, treatment became complicated or lacking and an otherwise good result was seriously marred. As stated, these resections were practically all done with the number 28 French sheath but with the present availability of a number 26 and 24 French sheath for the Nesbit instrument, it should be possible to avoid trauma to the urethra and still thoroughly resect the gland. We have seen no strictures due to the external urethrotomy itself as performed for transurethral resection, and the hospital stay of these patients was not prolonged; frequently no perineal urinary leakage occurred.

There appeared to be no direct correlation between the amount of tissue resected and the various complications in this series of cases. The experience

of the operator, however, was a considerable factor, particularly in relation to the more serious mishaps; the greater the experience, the fewer the complications.

SUMMARY

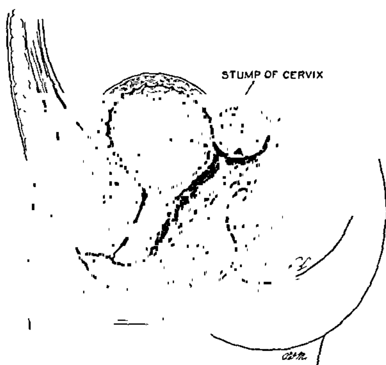
The immediate and later complications of 500 patients who underwent transurethral prostatic resection have been reviewed. The operative mortality was 1.8 per cent.

The prevention of hemorrhage, extravasation and sepsis still demands the close attention and skill of the surgeon, and measures to avoid the development of postoperative urethral strictures must be employed.

THE MANAGEMENT OF VESICOVAGINAL FISTULA

EARL E. EWERT

The vesicovaginal fistula, which resists a succession of efforts to close it, becomes, indeed, a seemingly hopeless situation both to the patient and to her family. *The discussion in this paper will be confined to the fistula resulting* from either partial or total hysterectomy found in a scarred bladder produced by injudicious and premature attempts at repair at the initial hospital entry.



Dissection
om the

The fistula is located at the apex of the vagina, the latter now contracted into leathery folds from multiple operations, infection and the constant bathing of urine (Figs. 342 and 343).

The patient usually relates that leakage of urine was apparent from the time of her operation or appeared some days from the time of surgery while she was still in the hospital. A history is frequently given that one and sometimes two *or three attempts were made to close this opening during her first hospital stay* with the inevitable failure as might be expected.

On vaginal examination one finds that the floor of the bladder in the region of the fistula is infiltrated and often the entire floor of the bladder is quite unyielding in character, no bladder floor remains beyond the fistula, and the

Originally published in Surgical Clinics of North America, 30 927–932 (June) 1950.

wall of the bladder and the wall of the vagina are continuous. That this occurs in many instances is not fully appreciated. At best there may be only a narrow shelf of bladder floor left, especially if repeated attempts have been made to repair the hole quite soon after the pelvic operation. The induration and scarring are quite apparent and on cystoscopic examination the location of the fistula can be seen to occur in the lower posterior wall of the bladder or in the posterior portion of the floor or both. In other words, this fistula may extend or include



Fig 343. After complete hysterectomy and repeated attempts at repair the vagina becomes narrow and contracted and visualization of the opening is almost impossible. The vesicovaginal septum is completely scarred and the intravesical anatomy distorted

the posterior margin of the trigone to well up on the back wall of the bladder. Frequently, the lateral margins of this fistulous opening may either border on the ureteral orifice or include in the edge itself so that all patients with vesicovaginal fistulas from whatever cause should have a preliminary cystoscopic examination. No doubt the inclusion of the ureteral orifice in the suture line must occur not infrequently in repairs which take place from the vaginal side. At this time, note is made of debris or encrusted exudate fringing the margin of these openings and plans are made to eliminate it by bladder irrigations and oral therapy.

A retrograde pyelographic study or excretion urogram can be done at this time to rule out disease of the upper urinary tract since the control of infection is mandatory and every possible approach must be planned to insure successful

repair because of so many previous failures. The lack of mobility of the bladder floor, the infiltration and scarring of the bladder and the juxtavaginal area

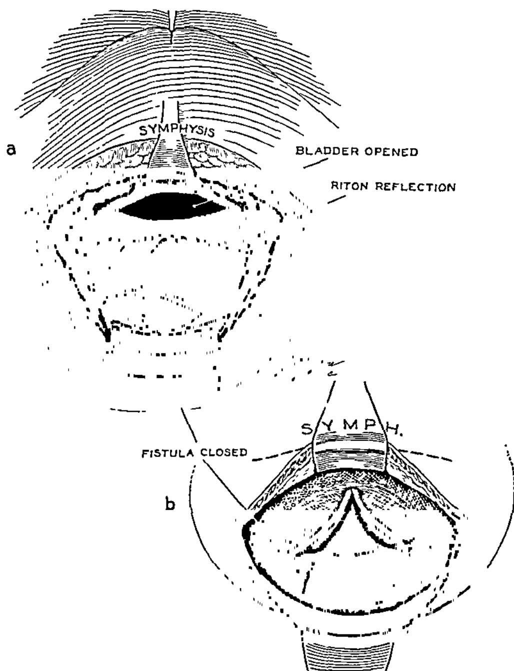


Fig. 344. *a*, Intra-abdominal attempts to segregate the area of repair between the bladder and vagina. The more completely these are separated from their fibrous union the greater the expectation of success. The peritoneum is used to buttress the suture line at the fistulous site.
b, If catheters are in place time is saved in determining the course of the ureters and latitude is allowed in dissection. Danger of injury of the ureters is ever present since distortion from scarring may alter their normal course.

that was involved in the original pelvic surgery can especially be appreciated and determined at the cystoscopic examination.

The lack of bladder floor and the anchoring of the posterior bladder wall to

the vagina must be corrected if success is to be attained at last. It must also be appreciated at this time that adequate dissection of bladder mucosa, muscularis, vesicovaginal septa and vaginal mucosa is impossible as all are bound by a most extensive callus that prevents adequate mobilization for repair.

Therefore, with such a fistula it is quite apparent that for any expectation of success in closing it there must be a most generous mobilization of the floor of the bladder, and, most important of all, the posterior bladder wall and that portion of the floor of the bladder must be freed from fixation to the apex of the vagina where that viscus is tied tightly. This can only be done by a combination of suprapubic and intra-abdominal avenues of approach.

The following method was pursued in 3 patients who had had from 3 to 7 previous attempts at repair after the original hysterectomy. Preliminary medication by mouth with one of the triple sulfas is carried out and twice daily douches of potassium permanganate instituted several days prior to operation. Since it is far easier to find the ureteral orifices cystoscopically than through the open bladder (Fig. 344), preliminary catheterization of the ureters is performed should there be any doubt of the ability to find them at the time of surgery when the bladder is open and to insert the catheters in place at that time. This done, the patient is placed in an exaggerated Trendelenburg position, the abdomen is opened through an incision opposite to the long axis of the recti, detaching these from the symphysis if necessary. The peritoneum is entered just at the apex of the bladder, the peritoneal incision following the circular outline of the bladder on each side laterally. The pelvis is isolated and separated from the abdomen by laparotomy pads as the bladder at this point is opened. This is done in order that, with the finger in the bladder, the reflection of the posterior bladder wall as it becomes the floor is accurately determined from the intra-abdominal aspect. This area is represented by a thickened and scarred peritoneum if the cervix has been removed or by the covered stump of the cervix if conservative hysterectomy has been done. The peritoneum is reflected exactly in the midline laterally in order to free the floor of the bladder from the vagina.

Since the success of this procedure is dependent upon generous mobilization of the floor of the bladder and its separation from the vagina, the catheters in the ureters mark well the lateral boundaries of this dissection. The vagina is necessarily entered into at this time and excessive scarring and unyielding tissue are well appreciated at this particular point. Since, as stated previously, there may be no floor to the upper margin of the fistula as the bladder may have been destroyed by attempts at closure, this provides the only route of mobilizing the posterior bladder wall, and what remains, if any, of this portion of the floor. The bladder is now dissected between the confines of the ureteral margin and careful palpation intravesically with the catheters in place guides the operator and allows him the latitude that he so badly needs and desires. The bladder is pulled up intra-abdominally and dissection thus facilitated. The vagina can be closed quite easily with running number 2 chromic suture reinforced by interrupted sutures if necessary. With the bladder pulled up in the abdomen by this freeing of the floor, the extent of the fistula can quite easily be seen and

repaired after freshening the edges. With the most accurate inversion, interrupted sutures can now be applied, taking healthy bites well away from the edges of the fistula and turning them in. The raw edges of the inverted opening intravesically may be reinforced with plain gut so that the mucosal surface of the bladder will not have a raw edge to bridge over during the healing process.

The peritoneum which has been incised overlying the posterier bladder wall and stump of cervix is now brought down and sutured in order to attempt to isolate more completely if possible the apical aspect of the vagina and the posterior bladder wall and floor (Fig. 345). The bladder is closed upon a mushroom catheter brought out suprapubically. A Foley bag catheter, number 24

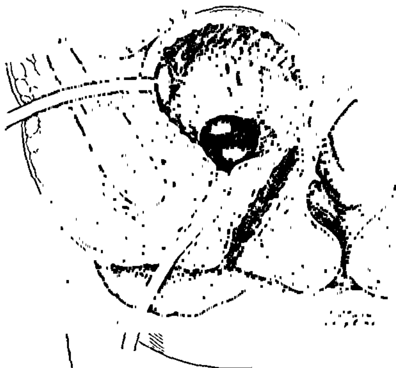


Fig. 345. By dissection, the vagina is allowed to descend somewhat and, at the same time, the bladder can be brought up, separating the sites of repair. Adequate two-way drainage avoids temporary obstruction of urinary diversion. The suprapubic tube can be removed in ten days.

French, is inserted through the urethra, so that adequate two-way drainage is assured.

Postoperatively, the suprapubic catheter is connected to a 1·10,000 potassium permanganate solution and no more than an ounce is let into the bladder four to six times daily in order to be sure that any clots or debris are kept free. The suprapubic catheter is removed from the seventh to the tenth day and the patient at this time is placed on a gentle suction apparatus and allowed out of bed. The suprapubic catheter is usually removed at the end of a week's time. If any undue vaginal discharge from repair is noted at any time, the vagina is cleansed again with the potassium permanganate solution. Sulfonamides and antibiotics are given postoperatively. If necessary, a culture can be obtained from the inlying urethral catheter and one of the oral antibiotics given. The inlying catheter is allowed to remain in place for approximately three weeks.

CONCLUSIONS

The causes of failures in repair of a vesicovaginal fistula occurring after pelvic surgery would seem to be: (1) premature and frantic attempts to repair it which are doomed to failure because of the brittleness of the tissues, the edema and acute local infections, inducing more scarring, contracture of the apex of the vagina and local destruction of the floor of the bladder; (2) high location of the fistula in the bladder and vagina, making visualization difficult, and (3) presence of exudative debris on the interior surface of the bladder in a freshly occurring fistula. This last mentioned cause alone forecasts inevitable failure by early repair.

Surgical repair must include a complete urologic survey, eliminating pathologic conditions of the upper urinary tract such as stricture of the ureter with infected hydronephrosis, and so forth. Inlying ureteral catheters should be used as a guide to forearm and assure the operator that he is proceeding laterally as much as possible, for complete mobilization when effecting closure seems most necessary. The intra-abdominal closure of the vagina separating it well from the bladder and the combined intra-abdominal intravesical closure of the bladder itself are most important. This allows for two-way postoperative urinary diversion to guarantee complete rest and absence of muscular contractions in the bladder so essential in plastic repair of the urinary tract.

THE BONES AND JOINTS

THE TREATMENT OF PRIMARY MALIGNANT BONE TUMORS OF THE HUMERUS

G. E. HAGGART

The first step in the management of suspected malignant tumors of the humerus is to obtain an accurate history, perform a careful physical examination and secure adequate roentgenographic studies. The next and very important step is a biopsy, taking care to avoid damaging the surrounding soft parts in so far as possible. If the preoperative clinical and roentgenologic examinations strongly indicate malignancy, then definitive treatment can be planned if a frozen section study confirms the diagnosis. If the preoperative findings are not clear cut, however, then only a biopsy is done. The final evaluation is determined after the permanent sections are studied.

With the diagnosis of a malignant bone tumor of the humerus established and in the absence of demonstrable metastases, or in selected cases as a palliative procedure, the patient is advised to have an interscapulothoracic amputation.

The operation of interscapulothoracic amputation has been condemned by some writers, but our experience with 5 cases does not accord with that opinion. Not only has the operation prolonged life in patients without demonstrable metastases, but also the procedure has prevented continued extreme suffering when employed simply as palliative treatment, as is so well illustrated by Case 2. If operation is decided upon, it is most important that the patient have a clear conception of the reason for such surgery and, likewise, definitely understand the very appreciable deformity that will result.

THE OPERATION

As reported in the literature when discussing interscapulothoracic amputation, the majority of writers have employed the "racket" incision and early ligation of the subclavian vessels, described by Berger. In our hands this approach has not proved satisfactory since the operator is working in a relatively deep hole and excessive bleeding is difficult to control. Following experimental dissections on the cadaver it was concluded that the simplest and most effective method of performing this operation is after the technic of H. Littlewood,[2] published in 1922. With some modifications, this procedure has been followed in operating on our patients, with satisfactory results.

The patient lies on his uninvolved side. The first or posterior (cervicoscapular) incision begins at the medial end of the clavicle just lateral to the insertion of the sternomastoid muscle, and extends laterally to the point of the shoulder, then sweeping downward along the axillary margin of the scapula to the angle of this bone whence it is prolonged toward the spine (Fig. 346,

Originally published in Surgical Clinics of North America, 27:717–728 (June) 1947.

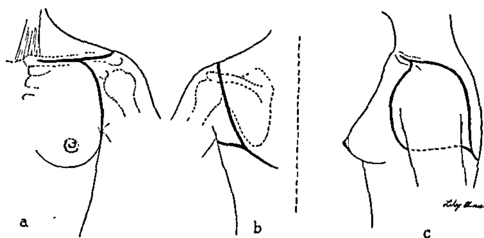


Fig. 346. Diagram of incisions—see text.

Fig. 347. Illustrating the posterior exposure and division of the trapezius muscle.

a and *b*). After subperiosteal dissection of the clavicle, the entire skin and subcutaneous tissue flap exposed by this incision are elevated toward the midline, revealing the posterior surface of the scapula. The inferior margin of the trapezius muscle is then identified and by blunt dissection freed from the underlying soft parts and the muscle divided between long, heavy intestinal type

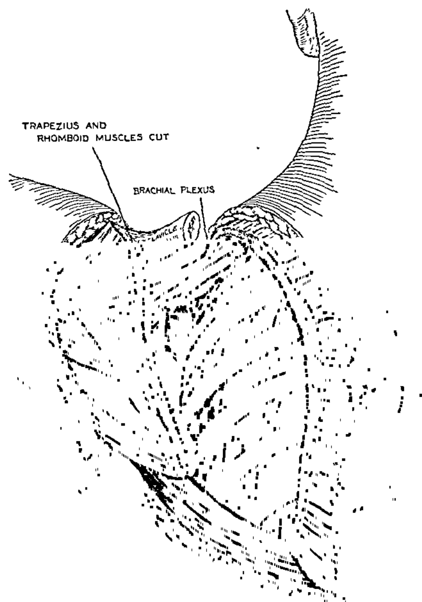


FIG. 348. Completion of posterior muscle division. Clavicle has been cut (see *text*) and arm allowed to fall forward, thus clearly delineating the brachial plexus and subclavian vessels.

clamps, the blades of which are covered with rubber (Fig. 347). In a similar manner, the omohyoid, levator anguli scapulae and rhomboid muscles are cut. With retractors, the vertebral margin of the scapula is then drawn upward and the fibers of the serratus magnus muscle divided close to the chest wall.

Following division of the inner end of the clavicle, the subclavian muscle is incised and then the extremity allowed to fall forward, thus exerting tension on the subclavian vessels and the brachial plexus, which are easily identified

and widely exposed (Fig. 348). Because the operator is not working down in a deep hole and there is minimal bleeding, this relatively simple method of identifying and treating the subclavian vessels and the brachial plexus is the keynote of the success of this procedure. The artery is first clamped and ligated,



Fig. 349. With exception of latissimus dorsi, all the anterior muscles have been divided. At operation the cut ends of the plexus and subclavian vessels are actually completely covered by the proximal flap.

then the vein, and thereafter the three large trunks of the brachial plexus are divided by the cautery. It is not necessary to inject the nerve trunks of the plexus with procaine. If desired, resection of a portion of the cervicodorsal sympathetic trunk can also be performed at this stage.

The surgeon now moves to the other side of the table, facing the patient, and the anterior incision is made, beginning at the middle of the clavicle, curving downward just lateral to and parallel with the deltopectoral group, crossing

the upper axillary fold and joining the posterior incision (Fig. 346, *c*). To minimize bleeding in a muscular individual it is particularly advantageous to dissect directly over the relatively delicate deep fascia covering the deltoid, trapezius and latissimus dorsi muscles. The pectoral muscles are divided about 2 inches (5 cm.) distal to their origin on the chest wall for cosmetic reasons, the latissimus dorsi similarly treated and, thereafter, the extremity and shoulder girdle removed (Fig. 349).

The skin, subcutaneous tissue and deep fascia are then closed in the usual manner, with Penrose tube drains in the dependent portion of the wound and a snug compression dressing applied. In this connection, an appreciable amount of blood can be saved the patient when the bone tumor is located in the upper third of the humerus by preoperatively wrapping the extremity, beginning at the finger tips, in an Esmarch bandage and then applying a tourniquet in the mid arm area.

RESULTS

Five patients have been operated on by the technic described. There has been no operative mortality. As illustrative of the two types of patients treated, a detailed case report of a patient without demonstrable metastases and a report on one patient in great physical distress with metastases to axillary nodes are presented, together with brief notes on the remaining cases.

REPORT OF CASES

CASE 1. A welder, aged 41, was admitted to the bone and joint department of the Lahey Clinic February 8, 1943, with the complaint of progressive pain and disability in the left shoulder which he attributed to a lifting strain that occurred in January 1942. He had been given various types of conservative treatment elsewhere, but disability continued to become progressively more marked.

Routine physical examination was entirely negative, as also were the blood studies, urine examinations and a roentgenogram of his lungs. The orthopedic examination was not remarkable save in relation to the left shoulder which exhibited pronounced generalized muscle atrophy and marked loss of motion. The maximal range of lateral abduction was 35 to 40 degrees He stated it felt as though there was a block *inside* the joint which prevented him from moving it, and there was moderate degree of pain.

The roentgenograms on admission (Fig. 350) revealed partial destruction of the head of the humerus and neck, with cystic changes and widening of the individual trabeculations. It was then felt that the diagnosis lay between some type of chondroma, caries sicca form of tuberculosis, or possibly an atypical Paget's osteitis. In view of the progressing disability and pain the patient was advised that a definite decision should be made and a biopsy carried out, to which he agreed.

On February 12, 1943, the left shoulder joint was opened through an *anterior incision* of the hockey-stick type (Fig. 351), preserving the deltoid musculature, carrying the dissection down between the deltoid and pectoral muscles. This permitted wide visualization of the joint capsule which, externally, seemed negative except over its inferior aspect where there appeared to be some fluctuation. The capsule was here incised parallel to the fibers of the internal rotator muscles, revealing a markedly hyperplastic synovial membrane of a gray-yellow color and a moderate increase in the amount of joint fluid. The head of the humerus presented numerous fissures and semidetached masses of cartilage were heaped up especially on the inner aspect of the head, acting



Fig. 350 (Case 1). Admission roentgenogram.

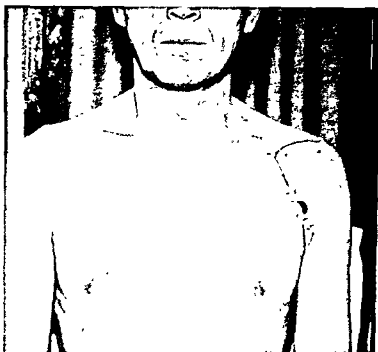


Fig. 351 (Case 1). Photograph illustrating a traumatic incision employed for exploration and biopsy of shoulder joint.

as a block to abduction, which process extended well into the bone of the head of the humerus. The glenoid fossa was negative and that portion of the proximal humeral shaft visualized was also negative. After removing specimens for microscopic examination, the wound was closed in layers and the wound healed.

After intensive study of the sections, Dr. Shields Warren, in consultation with Dr. F. B. Wolbach, reported that the process was a low-grade osteogenic sarcoma, which would not respond to radiation therapy.

After explaining the situation in detail to the patient and making clear what operation entailed, interscapulothoracic amputation was advised and accepted. Operation was performed March 10, 1943. From this procedure the patient convalesced uneventfully. Figure 352, *a* and *b* are photographs of the patient a week after operation.

During the ensuing two and a half years this man reported frequently for check-up examinations which were consistently negative. He was back at work, running a special

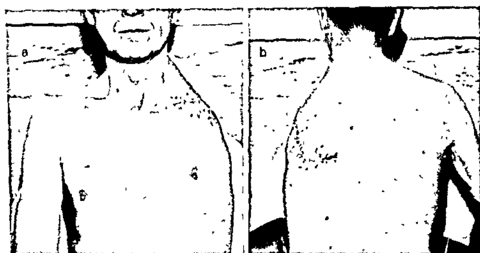


Fig 352 (Case 1). *a* and *b*, Photographs one week after operation.

electrical truck which he manipulated well and his income equaled that which he had received before his operation. June 25, 1945, he came in for one of his usual check-up examinations and at that time there was the first evidence in the roentgenograms of the chest of questionable areas of metastases. Clinically, the patient had no complaints and continued actively at work.

The patient was readmitted to the hospital December 24, and discharged December 31, 1945, with a history that in the past two weeks he had begun to experience shortness of breath and fatigue. Roentgenograms then revealed massive right pleural effusion and a circumscribed lesion in the lung field on the left. Four aspirations returned a total of 4500 cc. of bloody fluid which was negative for evidence of tumor cells. It was believed, however, that the process represented a metastatic malignancy. The patient died at home on January 27, 1946. An autopsy was not obtained.

Case 2.[1] A single woman, aged 68, was admitted to the clinic on April 5, 1940, with a history of gradual onset four to five months previously of intense, dull aching pain in the shoulder and arm and since then progressive swelling of the entire extremity, resulting in complete loss of function of the arm. Pain and swelling became so pronounced (Fig. 353) that by the time she was admitted she volunteered that the weight of the extremity had increased to such an extent and the pain was so severe she would welcome any type of treatment that would give relief.



Fig. 353 (Case 2). Preoperative photograph. Note marked swelling and edema of left arm. See text.



Fig. 354 (Case 2). Admission roentgenogram. Arrows outline soft tissue tumor mass.

A roentgenogram (Fig. 354) revealed an extensive osteolytic lesion of the upper end of the humerus as well as clearly illustrating the dense shadows of tumor involvement in the axilla so easily palpable on clinical examination, and especially along the anterior axillary margin and extending out over the posterior surface of the scapula. Metastatic malignancy seemed the most probable diagnosis. Every effort was made to establish the site of a primary lesion as well as to determine the presence or absence of other metastases. All of these studies, including roentgenograms of the skeleton, lungs, genito-urinary and gastrointestinal tracts, pelvic examination and blood studies, were entirely negative. It was, therefore, felt that this might well be a primary osteolytic sarcoma, and the patient was advised to have an interscapulothoracic amputation, not with the idea of a definite cure but rather to relieve her of the very marked discomfort then experienced and which would unquestionably become much more pronounced in the near future. On this basis she accepted operation.

Interscapulothoracic amputation was performed on April 29, 1940, by the technic described. The patient withstood the procedure extremely well and her convalescence following operation was uneventful.

Frozen section at operation indicated a highly malignant tumor, the exact character of which it was difficult to determine. Later studies by Dr. Shields Warren were reported as "rapidly growing malignant tumor, probably an atypical fibrosarcoma."

Following operation, the patient's course was followed at frequent intervals and then radiation therapy was started because there appeared to be recurrence of tumor in the lateral chest wall. The roentgenogram of the lung, October 22, 1940, revealed no evidence of metastases. The patient then stated she felt fine. Six weeks after this date, however, she reported shortness of breath and clinically gave evidence of respiratory embarrassment, and was therefore readmitted to the hospital where she died December 2, 1940.

An autopsy was performed and after extensive study of the sections obtained, Dr. Shields Warren reported that in his opinion the final diagnosis on this patient was Ewing's tumor of the left humerus with pulmonary metastases, the actual cause of death being a thrombosis of the right pulmonary artery and right renal vein. There was also evidence of a metastatic sarcoma to the skin of the left chest, left pleura, peritoneum and right periaortic nodes.

Case 3. A housewife, aged 31 years, was admitted July 29, 1943, because of painful swelling and disability in relation to the upper right humerus and shoulder joint area, of some two years' duration. A biopsy had been performed elsewhere April 19, 1942, and when we finally obtained these slides, the diagnosis by our pathologist was osteochondroma.

There was marked disability and loss of shoulder joint motion. The roentgenograms revealed an oval, soft tissue mass, 9 by 14 cm , lying largely lateral to the upper end of the humerus, with many irregular areas of calcification. The underlying cortex of the humerus was irregular on its external surface, but appeared intact throughout. The medullary cavity of the bone was not involved. Roentgenograms of the lungs were negative. It was believed that probably the tumor was malignant and an interscapulothoracic amputation was advised, providing frozen section confirmed this diagnosis. The patient refused and was, therefore, discharged.

Because of continued symptoms, the patient returned to the hospital December 11, 1943. It was then decided that in view of the biopsy done elsewhere and further roentgenologic studies, perhaps this was a benign lesion, an osteochondroma, and removal was carried out on December 20, 1943. The pathologic report revealed low grade

chrondrosarcoma. She still refused any further surgery and was therefore again discharged January 3, 1944, with the wound healed.

The patient returned May 15, 1944, at which time it was obvious that the tumor mass had recurred and markedly increased in size, hence confirming the diagnosis of malignancy. The patient then accepted interscapulothoracic amputation, which was performed on May 25, 1944, followed by an uneventful convalescence. She was discharged from the hospital June 7, 1944, the wound completely healed, and in excellent general condition. At no time had there been any evidence of metastases, either in the lungs or bones of the skull, ribs, pelvis, or long bones of the extremities.

On December 30, 1946, two years and seven months after operation, this patient was completely free of symptoms or evidence of metastases, and was carrying on her usual household duties.

CASE 4. A physician, aged 62 years, was admitted to the clinic May 28, 1943, with a persistent ulceration of the stump of the index finger of the left hand, of nine months' duration, with swelling of the arm and hand for three months. He reported that the index finger was injured on broken glass in September 1941. Infection thereafter followed and a finger amputation was done, following which he had no symptoms for a year, but in September 1942, he struck the stump of the finger against a table, and thereafter the infection again flared up, and had not healed since that time.

In summary, the clinical and roentgenologic examinations indicated evidence of bone invasion, with skin changes in the hand suggestive of epidermoid carcinoma. It was also felt that there was additional involvement in the nodes about the elbow and axilla. On June 9, 1943, tissue was removed from the fingers, as well as nodes from the elbow and axilla, which revealed an epidermoid carcinoma. An interscapulothoracic amputation was therefore advised.

Operation was performed on June 23, 1943, by Dr. Ralph Adams. The patient was discharged from the hospital July 4 of that same year with the wound healed and in excellent general condition. Microscopic studies revealed epidermoid carcinoma, Grade II, together with involvement of the removed axillary lymph nodes.

On July 24, 1944, clinical and roentgenologic examination showed the patient to be in excellent general health, and no evidence of metastases. He continued in active practice until June 3, 1945, when he suddenly became ill and finally died at home July 29, 1945, from widespread metastases.

CASE 5. A young man, aged 18, was admitted to the clinic September 18, 1946, with a complaint of ache and pains in the right shoulder and complete loss of function of the shoulder joint, of two months' duration. The onset was relatively rapid, for no known cause. The clinical examination and roentgenograms indicated there was a malignant lesion of the head of the humerus, of the osteoblastic type. Two weeks before admission he had been seen by another physician and a biopsy performed. These slides on examination by our pathologist were reported as osteogenic sarcoma. A roentgenogram of the lungs was negative.

The patient was advised to have an interscapulothoracic amputation which was performed on September 30, 1946. He convalesced without complications.

At the present time, six months later, clinical examination is negative, including a roentgenogram of the lungs. The patient is asymptomatic.

CONCLUSIONS

Proven primary malignant bone tumors of the humerus are best treated by interscapulothoracic amputation in patients without demonstrable metastases and in selected cases as a palliative procedure.

The preoperative diagnostic studies are briefly reviewed and the technic of the operation described.

Five cases are reported, two in detail. There were no operative deaths. The end results indicate this method of treatment is well worth while.

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CAUDA EQUINA TUMORS AS A CAUSE OF THE LOW-BACK SYNDROME

JAMES W. TOUMEY, JAMES L. POPPEN AND MELVIN T. HURLEY

In the ten-year period from January 1939 through December 1948, 48 patients with tumors of the cauda equina or of the low spinal cord were operated upon in the Department of Neurosurgery of the Lahey Clinic. In this same ten-year period, 1,056 intervertebral disk operations were performed at the Lahey Clinic. These tumors so frequently simulate disk lesions that it is believed an evaluation of this series of cases will be of interest to the orthopedic surgeon as well as to the neurosurgeon. These tumors represent a small group, 48 of 1,104 cases, or 4.3 per cent of the total. Since early, accurate differential diagnosis is of paramount importance for the prevention of permanent residual paralysis, this group, although small, is significant.

The difficulty of diagnosing these lesions has been recognized in the literature. Allen, reviewing the literature to 1930, noted that early recognition is of vital importance, because "it is only in the late and hopeless stages . . . that the classical clinical picture of a lesion of the cauda equina" is encountered. He found that 1 in 10 spinal-cord tumors affects the cauda equina. Because of the number of nerve roots which may pass through or surround the tumor, these lesions are difficult to remove. Allen stated that only in the early cases is successful removal possible. He noted difficulties in localization, because the cauda equina roots are perpendicular and tumors involving the cauda equina at different levels may give approximately the same symptoms and physical signs. Also, because of the width of the sacral canal, tumors may grow within the canal for a long time without producing neurological signs.

Love reviewed 26 cases of spine tumor which, as he so aptly says, "masqueraded" as protruded intervertebral disks. Fifteen procedures were done at the Mayo Clinic for spinal neoplasms; during this same period 100 disk operations were performed. In 8 of the 15 tumor cases the typical disk syndrome was present.

Cohen and Kaplan, in a review of 25 cases, noted the great similarity of the clinical picture in the group with cauda equina tumor and in the intervertebral disk cases. In addition, they noted that early diagnosis is not frequently made.

It is evident, therefore, that there is similarity in the clinical picture of tumors and disks. Thus the orthopedic surgeon is in danger of treating a cauda equina tumor with heat and massage, belts and braces, postural training and exercise, or even by spine fusion and disk exploration. It is because of the constant possibility of error in the treatment of common low-back conditions that this review has been undertaken.

Originally published in The Journal of Bone and Joint Surgery, 32–A:249–256 (Apr.) 1950.

In the authors' series of 48 cases, the sexes were evenly distributed, there being 24 of each; the average age was 41 years. The youngest patient was a girl of 14, in whom unilateral sciatica had developed four months before operation; at laminectomy she was found to have an ependymoma at the level of the third lumbar vertebra. The eldest patient was a woman of 68; she had had a radical mastectomy three years previously and metastasis had developed in the lumbar region.

SYMPTOMS AND SIGNS

Reviewing the classical signs of cauda equina lesions, Wechsler, in his textbook, noted that the cardinal symptom is pain, which may continue for a long

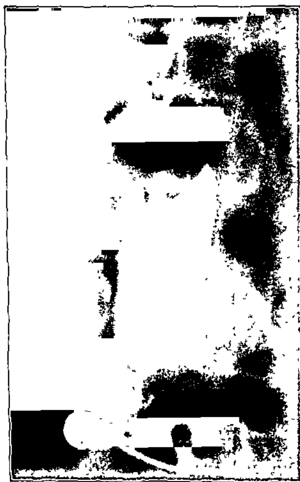


Fig. 355 (Case 35). Pantopaque myelogram shows definite block with cap formation at second lumbar vertebra, produced by ependymoma.

time before neurological signs appear, so that the tentative diagnosis of hysteria is sometimes made. Pain in the lower extremities is characteristic of lesions of the cauda equina. The pain radiates to the back or the front of the thighs or to the perineum, or it may be sciatic in nature. Sometimes it is restricted to the "small of the back." Later symptoms are muscle weakness, flaccid paralysis, and impairment of all forms of sensation. Wechsler stated that patients with low-spine lesions have relatively late involvement of the bladder and of the rectum, as well as late saddle anesthesia. If the lesions are higher—that is, in

the conus medullaris—the bladder and rectal changes are early and severe. Saddle anesthesia is present; ankle jerks are absent; the power of erection and ejaculation in the male is impaired; and there may be loss of pain and temperature sense. In lesions of the epiconus, paralysis of the feet is an early sign.

Thus, when the picture has become well established, the disease may have progressed to the late and hopeless stage.



Fig 356 (Case 8). Pantopaque myelogram shows block at the first lumbar vertebra, caused by glioma.

In spite of the many difficulties connected with establishing an early diagnosis, certain symptoms and signs are more suggestive of tumor than of disk lesion. In the authors' patients, an insidious onset of pain without a history of trauma, and an unremitting, progressive course definitely suggested tumor. The initial symptom of numbness in both legs is more frequently associated with tumor, as is early weakness of the lower extremities, especially when this is lateral. Bladder and rectal disturbances, when present, usually come so late that they are not helpful in the early differentiation of these conditions, and involvement of the sphincters is more often associated with tumor than with a disk lesion, but a large disk herniation appearing rapidly after trauma may immediately produce bladder and rectal changes. Patients with tumor are not so likely to have remissions as are patients with disk lesions. Pain that is constant, unrelieved by recumbency, and severe enough to prevent sleep at night is more

commonly associated with tumor. The patient with a ruptured intervertebral disk usually has recurrent attacks of sciatica, and he is usually able to obtain relief from pain while in the recumbent position.

The duration of symptoms from onset to date of operation varied in this series from two months in a patient with a widely disseminated leiomyosarcoma to

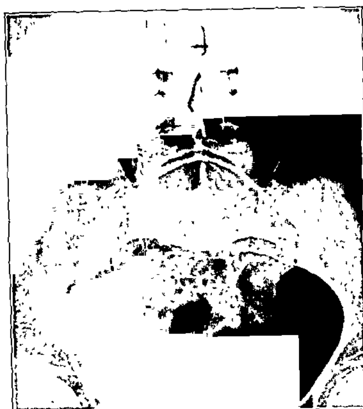


Fig. 357 (Case 37). Lumbosacral roentgenogram shows an oval defect in the sacrum, due to expansile tumor. The microscopic diagnosis was cyst with collagenous walls.

eight years in a woman of 56 years with a neurilemmoma. The average duration of symptoms prior to operation was twenty-five months. The incidence of the various symptoms, irrespective of when they appeared, is noted in Table 1, as are also the physical signs.

Table 1. Symptoms and Physical Signs in Tumor Cases

SYMPTOMS	NO.	SIGNS	NO.
Low-back pain	24	Absent or diminished ankle jerk	27
Unilateral sciatica	17	Sensory changes	24
Paraesthesia	15	Muscle atrophy	21
Weakness of legs	15	Positive straight-leg-raising test	19
Leg pain, other than sciatica	13	Muscle spasm in lumbar spine	11
Urinary and rectal symptoms, alone or in combination	10	Limited motion in lumbar spine	9
Night pain	5	Increased reflexes	7
Bilateral sciatica	3	Absent or diminished knee jerk	6
		Positive Babinski	4

The most common presenting symptom was low-back pain. The next most frequent symptom was unilateral sciatica, and the third was numbness of the legs. In addition, 6 patients had the primary complaint of vague leg pain and

2 had the initial complaint of weakness of the legs. Usually rectal and urinary symptoms appeared late.

Six patients, or 12 per cent, had no pain at any time. The primary complaint was numbness of the lower extremities. Spurling and Mayfield, *in a review of* 42 neoplasms of the spinal cord, found that 26 per cent of the patients had no pain.

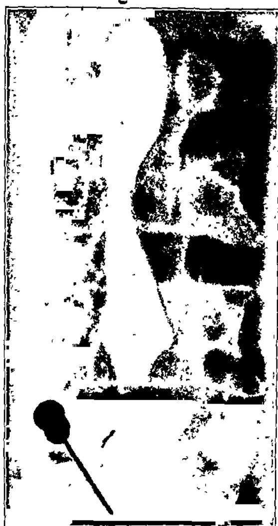


FIG. 358 (Case 32). Pantopaque myelogram. Filling defect is seen opposite body and disk of the third lumbar vertebra. The diagnosis was metastatic carcinoma from the right upper-lobe bronchus.

The most common single physical sign in this series of tumors (Table 1) was absence or diminution of ankle jerks, which occurred in 27 cases. Next were objective sensory changes. Since many of these physical signs are commonly found in intervertebral disk lesions, it may be impossible to distinguish between tumors and disk lesions on the basis of the symptoms and physical signs alone. In fact, tumors may become very extensive, especially the slow-growing ones, with little change in the lower extremities. This is illustrated by the 4 following cases, in which the neurological examination was completely negative.

CASE 1. A man, 58 years old, who had had low-back pain and sciatica for two years,

was found to have a neurilemmoma at the level of the fourth lumbar vertebra. He had no positive physical signs other than a list and limitation of motion of the lumbar spine.

CASE 5. A 14-year-old girl, who had an ependymoma at the level of the third lumbar vertebra, had no physical signs other than lumbar muscle spasm and a positive straight-leg-raising test on both sides.



FIG. 359 (Case 1). Oxygen myelogram with complete block at level of the fourth lumbar vertebra. The diagnosis was neurilemmoma.

CASE 23. A woman, 41 years old, who had had low-back pain, radiating into the thigh, for a year and a half, and progressive leg weakness for three months, was found to have a neurofibroma at the level of the third lumbar vertebra. The neurological examination was entirely negative.

CASE 37. A man, 46 years old, had had a history of sacral pain for nine months with

completely negative neurological findings. Roentgenographic examination showed that he had a defect in the sacrum, due to an expansile tumor. At operation a cystic lesion with collagenous walls was found.

Allen stated that there are no sensory changes in 23 per cent of cases.

Horrax, in presenting a series of 141 spinal cord tumors, noted that the lesions in the lumbar region may simulate those produced by a ruptured intervertebral



Fig. 360 (Case 34). Pantopaque myelogram demonstrates extravasation into communicating cyst at the level of the third lumbar vertebra.

disk. He stated that these patients had often been treated for a long time before the diagnosis was established, and emphasized the importance of careful neurological and lumbar puncture studies.

Several cases in the present series illustrate serious errors in diagnosis, as indicated by the following brief case reports.

CASE 9. A woman, 32 years old, had an intervertebral disk removed nine months

after the onset of sciatic pain. The pain continued to involve both legs. Three years later, when bladder and rectal disturbances began, roentgenograms demonstrated widening of the lumbar canal from the fourth lumbar vertebra to the first sacral vertebra, and an extensive neurilemmoma was removed.

Case 10. A man, 52 years old, had had lumbosacral backache for five years; the condition was not relieved by a spine fusion, done elsewhere, three years before. The



Fig. 361 (Case 17). Pantopaque myelogram shows block at first lumbar vertebra with cap formation. The diagnosis was neurilemmoma.

sciatica on the left persisted and later bladder and rectal disturbances appeared. An ependymal cyst was removed.

Case 11. A woman, 36 years old, had had low-back pain and sciatica on the left side for seven years. Coccygectomy, performed one year after the onset of symptoms, did not afford relief. Three years later bladder and bowel disturbances developed, and at

this time roentgenograms revealed changes suggestive of a chordoma; this finding was later verified by laminectomy. Complete removal was impossible because of the size of the tumor.

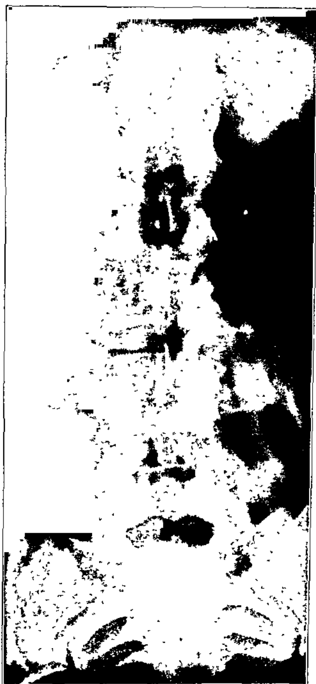


Fig 362 (Case 21). Oxygen myelogram with narrowing of column at third lumbar vertebra and destruction of facet at third lumbar vertebra on left. The diagnosis was metastatic thyroid carcinoma.

ROENTGENOGRAPHIC STUDIES

In this series, 27 patients had oxygen myelograms, 8 had pantopaque myelograms; and in 7 lipiodol was used. In 6 additional cases, myelograms were not done because the original lumbosacral roentgenograms were diagnostic.

In the authors' earliest cases, lipiodol was used; this was later supplanted by

oxygen to prevent any possible ill effects from the use of lipiodol. More recently, pantopaque has been found to be highly satisfactory in most instances.

Complete subarachnoid blocks were present in 19 instances and xanthochromic fluid was noted in 7 cases.

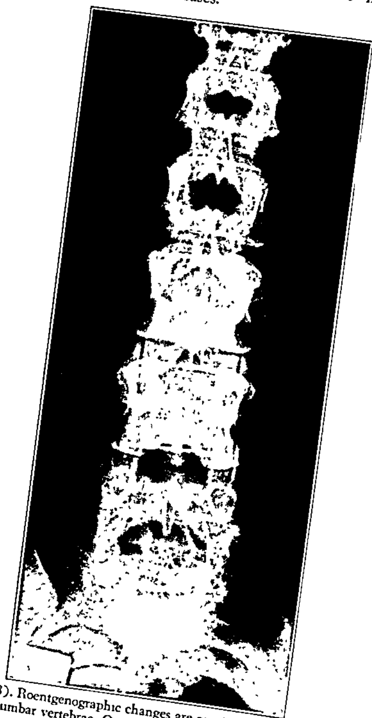


Fig 363 (Case 18). Roentgenographic changes are consistent with pressure on the pedicles of the first to third lumbar vertebrae Oxygen myelogram showed block at first lumbar level. The diagnosis was neurinoma

The authors feel that the single most important factor in the diagnosis of cauda equina lesions is the myelogram. In many cases, the history and physical findings are equivocal, but the use of contrast media establishes the differential diagnosis between a tumor and a disk lesion. The myelogram should be utilized as a routine in all cases of suspected disk lesion, in order that the patient can

be given the best and most complete investigation before surgical interference is instituted.

TOTAL PROTEIN

Estimation of the total protein is also of great value in giving weight to the myelographic findings. The values for total protein in this series varied from 14 to 610 mg. per 100 cc., the average being 140 mg.

MILLIGRAMS PER 100 CC.	NUMBER OF CASES
Over 200	9
100 to 200	9
45 to 100	9
Below 45	11

In 70 per cent of the patients the total protein was definitely increased, many of the readings being markedly elevated. The protein level was of great aid in diagnosis, since a markedly high protein is an unusual finding in association with a disk lesion unless complete block is present. However, tumors cannot always be relied upon to produce protein elevation, because normal findings were present in 30 per cent of the total.

PATHOLOGICAL FINDINGS

The classification of these tumors has been well described by Kernohan and his associates and by Grinker.

In the present series 10 patients, or approximately one-fifth, were found at operation to have malignant tumors (Table 2). The pathological findings in the

Table 2. Pathologist's Diagnosis of Tumors Found at Operation

MALIGNANT	NO.	BENIGN	NO
Leiomyosarcoma	1	Neurilemmoma	16
Lymphoma	1	Ependymoma	9
Malignant tumor, unclassified	1	Neurofibroma	4
Myxofibrosarcoma	1	Meningioma	2
Metastatic carcinoma		Fibrous cyst	2
Thyroid	1	Ependymal cyst	1
Bronchus	1	Chordoma	1
Prostate	2	Lipoma	1
Breast	1	Fibrosis	1
Neurogenic fibrosarcoma	1	Chronic inflammation	1
Total	10		38

remaining 38 cases showed benign tumors. Neurilemmoma was by far the most frequent (Table 2). This was present in 16 cases, or 42 per cent of those with benign lesions. Ependymoma was present in 9 instances, comprising 24 per cent of the benign lesions. A case of fibrosis is included, and also a case of pressure due to the previous use of lipiodol. Thus the tumors were of wide variety. A preoperative diagnosis of the type of tumor is well-nigh impossible.

SUMMARY

This review was undertaken to stress the ever-present possibility of serious error in the diagnosis of low back conditions, and to emphasize the difficulties in the diagnosis of cauda equina lesions.

Forty-eight cases of tumor of the cauda equina or low spinal cord are reported in which operation was performed at the Lahey Clinic between 1939 and 1948. In this same time interval, 1,056 intervertebral disk operations were performed. The tumors represent 4.3 per cent of the entire group. The patients with tumors ranged in age from 14 to 68 years; the numbers of males and females were equal.

Early diagnosis is of paramount importance in the tumor cases. There is great similarity in the clinical picture of tumors of the cauda equina and disk lesions.

Insidious onset of pain with an unremitting course definitely suggests tumor. Numbness and weakness of the legs is more often associated with tumor. The duration of symptoms varies from two months to eight years. The most common first complaint was low back pain, but 12 per cent of the patients had no pain whatsoever.

The most common physical sign in the tumor cases was an absent or diminished ankle jerk, but this finding is common in disk lesions, also. Tumor lesions cannot usually be differentiated from disk lesions by physical signs. In 8 per cent of the tumor cases, neurological signs were not present.

The myelogram is the most significant and valuable aid in the differential diagnosis. The use of pantopaque, removed at the time of fluoroscopy, is preferred at the present time.

Estimations of total protein ranged from 14 to 610 mg. per 100 cc., the average being 140. A protein determination of over 100 definitely suggests tumor and is a valuable diagnostic aid. However, in 30 per cent of the patients who had tumors, the total protein was not elevated.

In this series, 20 per cent of the tumors were malignant. Of the benign tumors, neurilemmoma was by far the most common, with ependymoma second.

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THE SURGICAL TREATMENT OF FRACTURES OF THE LATERAL TIBIAL CONDYLE

G. E. HAGGART AND HOWARD M. CLEMMONS

Fracture of the lateral condyle of the tibia can be and often is a cause of marked permanent disability, because in the more severe injuries, which so frequently occur, there is comminution of the articular cartilage with dissolution of the spongy bone below, together with tearing, crushing or displacement of the lateral meniscus. The failure to remove the damaged meniscus and then accurately reduce the fracture results in knock-knee deformity, lateral instability, and a persistent chronic synovitis.

Fractures of the lateral tibial condyle are the result of sudden abduction of the tibia on the femur and are caused by: falls from a height; a twisting injury, or the most common agent—a blow on the lateral side of the knee, from the bumper or fender of an automobile as reported by Cotton and Berg[3] and by Cubbins, Conley and Seiffert[4] in 1929. These authors also emphasized the frequency with which the lateral meniscus is injured, pointing out that it might be jammed down in between the fragments of the tibia, thus preventing any possibility of accurate, closed reduction.

An additional reason for operative exposure of all severe fractures of this type and many of the ones of questionable severity is that the roentgenograms do not accurately reveal the extent of the injury because of the overlying bone shadows. For example, in an anteroposterior view, the posterior rim of the lateral condyle casts a shadow which may obscure the degree of the depression of the central and anterior aspects of the lateral plateau, while the lateral roentgenogram as such is usually of little value because of the overlapping shadows from the medial condyle. Anteroposterior stereoscopic and right and left oblique roentgenographic projections have been found most helpful.

With a normal level of the condylar plateau of the tibia, the stability of the knee joint depends upon the integrity of the strong supporting ligaments, particularly the lateral and medial collateral ligaments together with the surrounding muscles, whereas in the presence of a depressed surface of this condyle these ligaments and the muscles as well are at a marked disadvantage. Disability from this fracture is accentuated by the fact that the normal medial inclination of the femur causes more stress on the outer than on the inner femoral and tibial condyles.

TREATMENT

The management of fractures of the lateral tibial condyle can well be considered under the classification reported by Barr,[1] together with one additional group, later emphasized by Cave.[2]

Originally published in Surgical Clinics of North America, 29 893–903 (June) 1949.

Type A, in which careful roentgenograms reveal less than ¼ inch displacement, is best treated by suspension, together with aspiration of the joint as seems indicated. Close-fitting plaster casts may be used. It is important to institute early active exercises of the quadriceps muscle groups and in two weeks begin active motion of the joint. An intelligent, cooperative patient may be allowed up with crutches in six to eight weeks but no real degree of weight bearing is permitted for ten to twelve weeks.

Type B, wherein the roentgenograms exhibit slight to moderate displacement of ¼ to ½ inch, is the group in which there is a question as to whether the fracture site should be explored or handled on a conservative basis. In most instances we have favored open exploration because, as noted above, the roentgenograms so consistently failed to reveal the actual extent of the pathologic process. On the other hand, it is fair to point out that some patients who exhibited a fracture approaching a ½ inch displacement and for whom we believed surgery advisable have achieved an excellent clinical result although the roentgenograms show far from an anatomical reposition of fragments.

Type C, moderate to marked displacement, in other words, ½ inch or more, is the group in which open operation is always indicated, because closed reduction and manipulation simply result in impaction of the central fragments in a displaced position.

Type D is the group in which there is extensive comminution of the entire upper end of the tibia or what has been termed a bursting fracture. In these patients the tibia is so shattered that an open procedure is ill-advised. They are primarily treated by skeletal traction through the lower end of the tibia, together with gentle manipulation under anesthesia at the time of the application of the traction. This program also offers the possibility, once healing has occurred, and if the plateau level is not restored, of later operating to replace the condylar surface.

TECHNIC OF OPERATION

The fracture site is exposed (Fig. 364) by a lateral incision running in front of the fibula and lateral to the patella as described by Leadbetter and Hand,[5] extending sufficiently above and below the joint line to permit good visualization of the fragments as well as to allow access to the proximal aspect of the tibia so that a bone graft may be obtained. A tourniquet is employed.

The joint is thoroughly washed out with saline solution to remove blood clots and then the fracture site is inspected after subperiosteal dissection of the exposed portion of the tibial condyle, leaving the soft parts attached to the lateral fragments of the tibia. The injured lateral meniscus is first removed *in toto,* thus allowing a still better view of the fractured articular surface of the tibia; it is then possible, with the use of elevators, to reposition the depressed plateau and this is further expedited by cutting a small window in the proximal anterolateral aspect of the tibia which will permit a blunt instrument to press against the inferior surface of the condyle. In addition, once the fragments are repositioned, cancellous bone removed from the upper end of the tibia is packed into this space, utilizing the opposing lateral condyle of the femur as a surface against which to press.

down of the entire articular surface of the lateral tibial condyle. The posterior rim of the plateau had been broken up into multiple fragments. Anteriorly the rim was part of a large triangular fragment which had been displaced outward and downward. The central portion of the plateau immediately adjacent to the tibial spine had been im-



Fig. 366 (Case 1). *a* and *b*, Three years and nine weeks after open reduction. Knee joint motion is normal and the patient is asymptomatic. Note absence of any reaction about the bolt.



Fig 367 (Case 2). *a*, Old, markedly displaced fracture of the lateral tibial condyle. Original injury, August 26, 1944, operation January 6, 1947. The opposite knee is shown for comparison (*b*).

pacted distally. The lateral semilunar cartilage (and this is important) was imbedded in several places in the fissures and fractures of the tibial plateau.

Following removal of the external meniscus the fragments of the articular surface of the tibial condyle were replaced in position, then the large lateral fragment was aligned and held by a transverse bolt.

The operative wound healed by first intention and when last seen on December 17, 1948, the patient was completely asymptomatic in regard to the knee, and had a normal range of motion. The roentgenograms (Fig. 366, *a* and *b*) revealed a normal articular surface and contour of the lateral tibial condyle.

CASE 2. This 34 year old housewife was admitted to the clinic on April 3, 1945, with a variety of symptoms and, in relation to the left knee, a sense of weakness and instability of some seven months' duration. She had been thrown from a truck, and thereafter one of the wheels of the truck passed over her leg (August 26, 1944). On clinical examination she exhibited a very unstable joint with marked weakness of the quadriceps musculature. Roentgenograms (Fig. 367) revealed a downward displacement of the external condyle of the left tibia. The patient also was found to have essen-



Fig. 368 (Case 2). *a*, *b*, and *c*, One year and three weeks after open reduction. Plateau level has been maintained, and bone grafts (see text) are almost indistinguishable. Note site of removal of bone grafts from the tibial shaft. Patient had normal range of motion and a stable joint.

tial hypertension as well as chronic cystic mastitis. She was, therefore, originally admitted to the hospital for a right and then a left splanchnicectomy, followed by excision of the mastitis. During this period she was given intensive muscle exercises and instructed to lose weight, as she was definitely obese.

With return of the blood pressure to a normal level, the patient was readmitted to the hospital. On January 6, 1947, the knee was operated on and a heavy cortical graft of tibial bone was placed underneath the osteotomized lateral condyle which had been lifted into position. Eight weeks later, manipulation of the knee was carried out to expedite obtaining increased range of motion.

When the patient was last seen January 27, 1948, the roentgenograms (Fig. 368) anterior, posterior oblique and lateral views, revealed maintenance of the plateau level. The joint was absolutely stable, and examination of the knee was negative and the range of motion normal. The patient's only complaint was of fatigue of the extremity when she was tired, but it was our belief that this was because she had not properly carried out her muscle training, and she was therefore instructed to resume it more vigorously.

CASE 3. A 20 year old secretary was admitted to the orthopedic service on April 10, 1946, following an injury sustained when struck by a motor car thirty-six hours previously. She arrived at the hospital in a long-leg plaster cast.

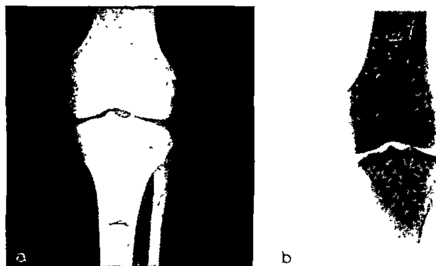


FIG. 369 (Case 3). *a* and *b*, Comparative roentgenograms of the injured (*a*) and noninjured lateral tibial condyle. Note the marked depression of the entire lateral tibial condyle (*a*) without any clear-cut evidence of a fracture line. The joint was extremely unstable.

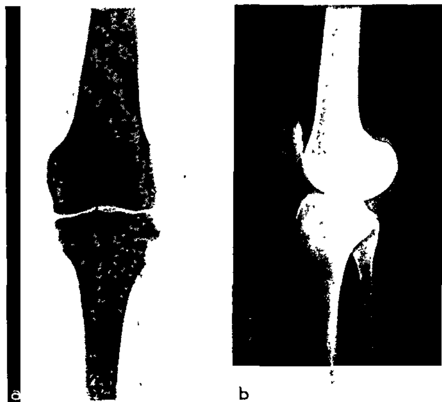


Fig. 370 (Case 3). *a* and *b*, Two years and eight months following open reduction. Bone grafts are still evident. The knee joint is stable and painless.

Clinical examination revealed marked abnormal mobility in the knee joint and the roentgenograms (Fig. 369, *a* and *b*) exhibited, in comparison with the opposite or uninjured knee, pronounced compression fracture of the entire lateral condyle of the left tibia.

At operation, on April 22 of the same year, numerous fissure fractures were seen running throughout the cartilaginous surface of the lateral tibial condyle, in one of which the semilunar cartilage was partly buried. In addition, this cartilage revealed a longitudinal split throughout its posterior two-thirds.

Following removal of the external meniscus, the cartilaginous surface of the lateral tibial condyle was lifted up by an osteotomy of this part of the bone carried out parallel to the articular surface, employing the central portion of the condyle as a hinge. A triangular piece of bone cut from the tibia was inserted into this defect and trimmed to fit.

The patient convalesced uneventfully following this procedure and when last seen January 8, 1949, the roentgenograms (Fig. 370, *a* and *b*) showed the graft incorporated



Fig. 371 (Case 4). *a* and *b*, Oblique and anteroposterior roentgenograms of a three-week old, extensively comminuted, depressed fracture of the lateral tibial condyle.

within the tibia and the general level of the plateau was maintained. The knee joint was stable and painless. The patient's range of motion was from normal active extension to a flexion of 20 degrees beyond a right angle. She lacked at least 20 degrees of complete flexion as compared with the opposite side, which in our opinion was attributable to the difficulty that was encountered throughout our experience with the patient in having her carry out her exercise program.

CASE 4. A 31 year old housewife with a known history of diabetes mellitus was admitted to the orthopedic service on July 23, 1948, with a history of a twisting injury of the knee that occurred three weeks before admission and from which she was com- [illegible] a depressed comminuted fracture of the external condyle of the tibia together with displacement of the lateral fragments of the condyle.

On July 27, 1948, open reduction of the fracture was performed, with removal of the obviously damaged lateral meniscus and elevation of the markedly comminuted fragments of the tibial condyle. Postoperative convalescence was uneventful. Originally placed in a long-leg plaster cast because of the extensive comminution of the fragments

that was so pronounced it was not possible to utilize bolt fixation, and in which apparatus it was necessary to maintain the extremity until there was beginning evidence of healing, the joint was then progressively mobilized. When the patient was last seen February 4, 1949, the roentgenograms (Fig. 372, *a* and *b*) showed healing of the fracture, now over six months since operation, with maintenance of the tibial plateau. There was no evidence of swelling on examination and the patient was free of any pain or discomfort. She exhibited normal extension and flexion within 10 degrees of the

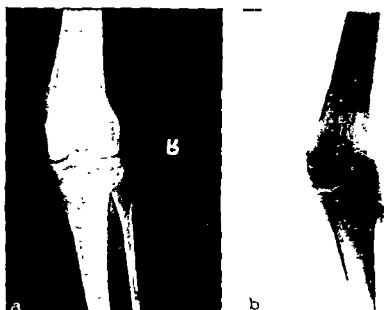


Fig. 372 (Case 4). a and b. Comparable roentgenograms six months after open reduction. [illegible] ling on motion. [illegible] extension and lacked 10 degrees of flexion as compared with the opposite knee, but it is believed that in the very near future she will establish normal range of flexion.

range present in the opposite or uninjured leg. The quadriceps musculature was still weak but was rapidly regaining tone and strength. The prognosis appeared favorable.

SUMMARY

Fractures involving weight-bearing joints should be restored to normal anatomical relationship as accurately as possible. To meet this criterion in fractures of the lateral tibial condyle with moderate or marked displacement of fragments, it is necessary to expose the fracture site, with the single exception of the so-called bursting type of fracture, which is treated by skeletal traction.

The operative approach is additionally indicated because the roentgenograms do not accurately reveal the extent of the injury owing to overlapping of the bone shadows.

It is admitted that some patients with moderate displacement of fragments who refused surgery have obtained a satisfactory functional result, although the roentgenograms continue to show an appreciable depression of the tibial plateau. Nevertheless, presented with a fresh fracture of this degree or more, we strongly subscribe to the opinion that surgical treatment offers the best prognosis.

The technic of operation together with management following surgery is described.

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THE MANAGEMENT OF CHRONIC SUPPURATIVE OSTEOMYELITIS OF THE FEMUR

G. EDMUND HAGGART AND MELVIN T. HURLEY

Since the antibiotics have become available, notably penicillin, the treatment of chronic suppurative osteomyelitis has been changed from that of the technics previously employed. However, in patients with infections of long duration, particularly in those individuals who present involvement of the femur, we concur with Buchman and Blair[1] that it is essential to combine surgery with drug therapy in order to achieve a satisfactory result.

It is the purpose of this paper to present our experience and the results obtained in the treatment of long-standing chronic osteomyelitis of the femur in 21 consecutive patients. This is admittedly a small series; nevertheless, these patients illustrate the severe systemic reaction consequent upon such an infection together with the details of management which with one exception have saved the extremity and led to complete healing.

PROCEDURE

A detailed and thorough history is taken and a physical examination carried out including complete blood counts, urinalysis and sedimentation rates as well as blood grouping. In those individuals with a draining sinus present bacteriologic investigation is done including sensitivity tests on the dominant organism with penicillin and streptomycin.

The next and a most important step in this preliminary study is an injection of diodrast into the sinus tract performed in the Department of Radiology where stereoscopic anteroposterior and lateral views of the involved area are obtained. (Fig. 373, *a* to *d*.) Since one of the major objectives at surgery is excision of the sinus tract, it is most important in planning the operation that as accurate an idea as possible is obtained of the extent of the tract as well as illustrating the particular area of bone involved. So strongly do we believe on this score that three patients (not included in this series) admitted during the past year with a sinus tract recently healed were repeatedly observed until the sinus again opened and this injection could be carried out.

Before surgery the patient is given whole blood transfusions to restore a more normal blood picture as without exception all patients in this series exhibited a degree of anemia sometimes quite pronounced. Furthermore, administration of the selected antibiotics as determined by the sensitivity test is begun forty-eight hours in advance of surgery and continued therafter as seems indicated. In this series the hemolytic Staphylococcus aureus was isolated in 34 per cent and the nonhemolytic staphylococcus in 46 per cent of the patients, hence

Revision of article originally published in the American Journal of Surgery, 78.591–596 (Nov.) 1949.

penicillin was the agent of choice. The dosage averaged 3,000,000 units every twenty-four hours. Later, for the comfort of the patient and with satisfactory

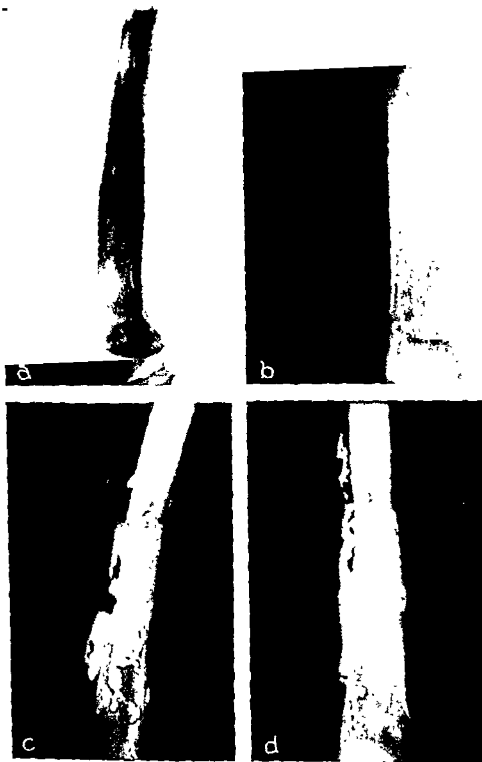


Fig. 373 (Case E. G.). Chronic suppurative osteomyelitis of eleven years' duration. *a* and *b*, Admission roentgenograms; the oval defect in the bone is the result of previous surgery elsewhere. *c* and *d*, Extent of sinus tract is shown following injection with diodrast.

progress, it was shifted to 600,000 units of crysticillin given in two equal doses over the same interval.

OPERATION

Following appropriate preparation the first step is to inject the sinus tract with methylene blue under considerable pressure. In the presence of multiple sinuses every effort is made to block their exits temporarily so that the entire tract can be thoroughly impregnated with the dye. This procedure has been of great assistance in accurately delineating the walls of the tract so that all of it may be excised.

A direct lateral approach to the femur, splitting the fibers of the vastus lateralis just above the lateral intermuscular septum, has been found most satisfactory. In those instances when the bone infection was confined to the



Fig. 374 (Case E. G.). *a* and *b*, Postoperative roentgenograms illustrating the amount of infected bone removed, the previous operative defect shown in the anteroposterior view was not disturbed as it was simply a window in the bone with no immediately adjacent active infection

distal portion of the femoral shaft, the vastus lateralis was displaced anteriorly. There is initially considerable bleeding but this can be quickly checked by careful hemostasis; its effects are also combated by transfusions given during the procedure. We do not favor the anterolateral approach in these patients because of later limitation of knee joint motion due to adhesions of the quadriceps musculature to the shaft of the femur. Posterior exposure of the bone is not acceptable because of possible involvement of the sciatic nerve in the infection and scar as pointed out by Bosworth.[2] A tourniquet is not employed.

The only instances in which we have utilized a more anterior incision were in those patients with osteomyelitis of the proximal third of the femur when the dissection was carried down between the sartorius and tensor fascia femoris muscles.

Following removal of the sinus tract the femur is carefully inspected and the findings checked with those on the x-ray film. Series of drill holes are made

in the cortex to outline the area of involved bone which is then removed by connecting the drill holes with an oblique osteotome and a motor saw. It is not only necessary to remove all of the obviously infected bone and sequestra both within and outside of the marrow cavity but also sufficient bone is cut away to make certain that no "pooling" may form after the wound is closed. (Fig. 374, *a* and *b*.) In other words it is essential to excise part of the lateral and posterior cortex in the area and in some instances may be necessary to take out a portion of the medial cortex.

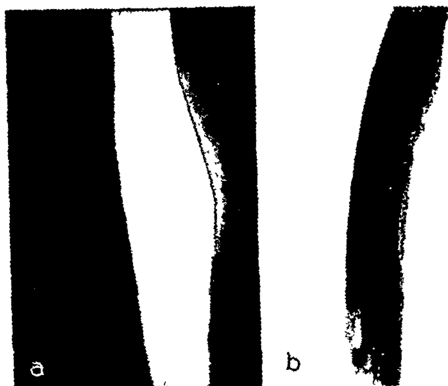


Fig. 375 (Case E. G.). *a* and *b*, Four years five months after surgery; patient asymptomatic; note regeneration of bone.

After thorough cleansing of the wound with saline irrigations anteroposterior and lateral portable x-rays are taken to determine whether an adequate excision of infected bone has been performed and also to make certain that there are no bone fragments left in the wound. The latter is particularly prone to occur because the bone in question is so sclerotic that it splinters and small fragments of bone may be overlooked in the soft tissues unless check-up x-rays are taken.

Following the final review of the entire field for bleeding points the wound is firmly closed in layers without drains. If a large operative defect in the femur has been created, the patient is initially placed in a single plaster hip spica, otherwise in suspension and adhesive traction applied to the skin of the lower leg.

Muscle transplants to fill in the bone defect as suggested by Starr[3] and Prigge,[4] have not been utilized in this series because our experience with this procedure in patients treated prior to this group was not particularly successful. No attempt has been made to pack the defect in the femoral shaft with bone chips. This may be an additional technic of value but in the first patients of this series it would have been necessary to obtain bone from another site in the

same patient. In consideration of the magnitude of the combined procedures this was considered ill-advised. Now with the aid of the bone bank such an additional step is more feasible. On the other hand our experience with the rate at which adults regenerate bone (Fig. 375, *a* and *b*) has been such that at present we are not utilizing the bone bank facilities for these patients.

COMPLICATIONS

As shown in Figures 376 and 377, *a* and *b*, the shaft of the femur is weakened by wide removal of bone over an extensively involved area. This particu-

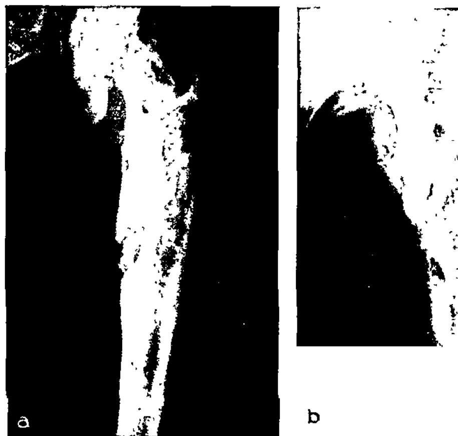


Fig 376 (Case R. T. D.). *a* and *b*, Admission roentgenograms with diodrast injection; osteomyelitis of five years' duration subsequent to a series of boils, multiple sinus tracts present.

lar patient suffered a fracture of the proximal shaft at the time of surgery which was thereupon plated (Fig. 377, *a* and *b*) and the wound healed by first intention. Seven months later he was asymptomatic but in an automobile accident he refractured the femur in an area just above the previous fracture which was healed; the fragments fortunately were held by the upper end of the plate. (Fig. 378, *a* and *b*). From this the patient also recovered without incident and despite the additional trauma he has not at any time exhibited signs of recurrent osteomyelitis during the twenty-eight-month period of follow-up. (Fig. 379, *a* and *b*.)

One other patient who healed by first intention sustained a fracture through the saucerized area of the distal femoral shaft twenty-two months after surgery as the result of a severe fall. The x-rays then and since that time, thirty-nine months since his operation, have shown no further evidence of active osteomyelitis.

There have been no incidents of postoperative embolism or thrombosis. When the area of bone removal was adjacent to the region of the femoral condyles, there was a temporary loss of knee function but in every instance the preoperative range of motion was regained.



Fig. 377 (Case R. T. D.). *a*, Portable roentgenogram taken in operating room illustrating the large amount of bone that had to be removed so that the patient sustained a fracture which was thereupon plated. *b*, Short proximal screws penetrate all that remained of the cortex. In the preparation of the x-rays the films were inadvertently reversed.

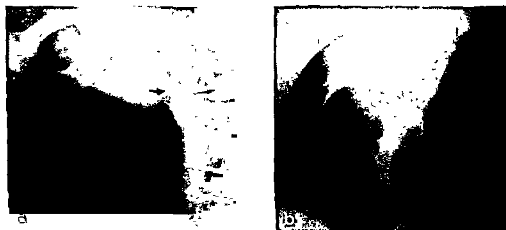


Fig. 378 (Case R. T. D.). *a* and *b*, Seven months following surgery the patient refractured the femur in an automobile accident; note the previous fracture healed and the extensive regeneration of bone. The fracture line is not visible in lateral projection.

ANALYSIS OF END RESULTS

In this series of 21 consecutive cases of chronic suppurative osteomyelitis of the femur there were 12 males and 9 females, with an average age of 27 years for males and 35 years for females. Fifty-four per cent of the cases involved the right femur and the left femur was infected in 47 per cent. The average

duration of symptoms in all cases was nine and a half years ranging from a maximum of twenty-eight years to a minimum of one year. Sixteeen patients, 76 per cent, presented draining sinuses in the region of the involved bone. The disease was of hematogenous origin in all instances except in 3 patients. In 1 infection followed a gunshot wound; in the remaining 2 infection was the result of open reduction and internal fixation of fractures performed elsewhere.

Of the total series 16 or 76 per cent healed by primary intention and have remained healed and symptom-free for an average period of 2.7 years. The longest follow-up on any one of these patients healing by first intention was nine years, the shortest eleven months.

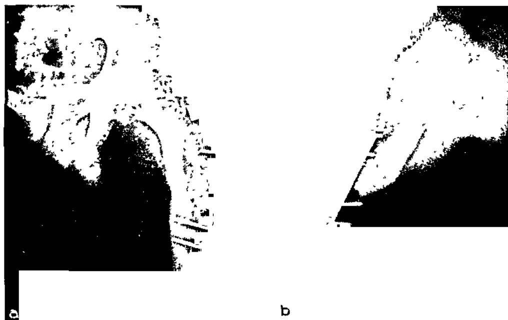


Fig 379 (Case R. T. D.). *a* and *b*, Three years four months following the operation; patient asymptomatic with normal range of hip and knee motion.

The results in 4 patients as compared to those previously noted have been classified as good. All healed by first intention following surgery but developed subcutaneous abscesses in the scar from three to nine months after operation. In each instance these were localized processes. The x-ray revealed no evidence of active bone infection nor at the time the abscess was incised and drained, which was the treatment plus a ten-day course of penicillin, was there any evidence that the abscess communicated with the femur. Since incision and drainage in these 4 patients they have remained healed and have been asymptomatic for a period ranging from one year in the most recent case to six years in the longest follow-up.

In a fifth patient, a failure, delayed healing occurred but in one year's time the process again became very active; the sinuses reappeared and this patient eventually came to thigh amputation. Two years following this procedure he was asymptomatic and ambulatory with a well fitted prosthesis. It is our belief that in this instance the failure was the result of a combination of factors, viz., the patient was a sedentary, overweight male of 49 who gave a twenty-eight-year history of suppurative osteomyelitis of the left femur with multiple draining

sinuses and repeated operations. When he was admitted to the hospital October 23, 1945, the anterolateral soft tissues of the thigh presented an almost board-like rigidity due to extensive scar formation. Among the organisms cultured was a persistent Friedländer's bacillus which became resistant to streptomycin. When the patient was first operated upon on November 13, 1945, this particular organism was found only at the time of surgery. Previous cultures of the sinuses had not revealed it. Streptomycin was then available in comparatively minimal amounts. We were fortunate in being able to obtain 1,000,000 units which in combination with penicillin and surgery led to complete closure of the sinus tract. The patient's general condition was then noted as satisfactory only to have a recurrence a year later.

CASE REPORT

The following case report illustrates the steps in the development of our present plan for the management of chronic suppurative osteomyelitis of the

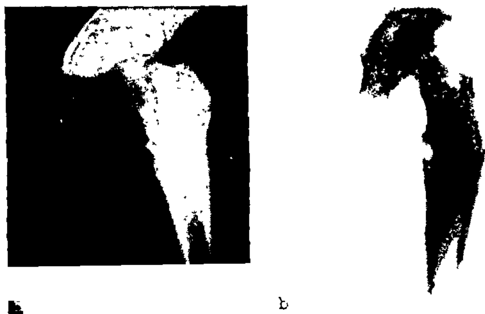


Fig. 380 (Case R. S.). *a*, First admission roentgenogram; note area of bone destruction about the region of the lesser trochanter. *b*, Postoperative film; note bone removed in region of lesser trochanter.

femur. This patient was under treatment both before and after penicillin became available. In the first procedure the patient was given intensive sulfathiazole therapy while the surgery was not as radical as is now believed indicated.

R. S., a male student of 18, was first seen November 23, 1942, because of an acute suppurative osteomyelitis of the femur with large abscess formation in the proximal thigh and with an area of bone destruction about the lesser trochanter together with sclerosing osteitis of the proximal shaft of the femur. The patient stated the first symptoms occurred in September, 1941, following a severe blow on the upper left thigh while playing football. There was no soft part abrasion or wound. He was at that time given sulfonamide drugs, put in a cast for an interval and was thereafter completely asymptomatic for one year when a small abscess developed in the upper thigh and drained for a few days. After this he again felt well until one week before admission

when another abscess appeared. For this he came under our supervision. (Fig. 380, *a*.)

Following intensive sulfathiazole administration, operation was performed November 27, 1942, when a very large subcutaneous abscess in the anterolateral left thigh was drained. From it a tract led to an area of bone destruction involving the lesser trochanter

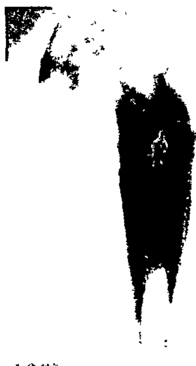


Fig. 381 (Case R. S.). Film on second admission; large abscess cavity of proximal femoral shaft is evident.





Fig. 382 (Case R. S.). *a* and *b*, Roentgenograms following the second and definitive procedure.

in which there was a cavity which contained a teaspoonful of pus. The walls of the abscess cavity, sinus tract and area of involved bone were excised and the wound healed by first intention. Figure 380, *b*, is a roentgenogram taken January 21, 1943, when the patient was ambulatory on crutches and progressively increasing activity.

This man thereafter remained well until August 20, 1943, when a small sinus developed in the lateral proximal left thigh from which he reported some slight initial discharge. However, when seen on the date noted there was none nor was there any evidence at that time of active bone infection. The sinus promptly closed and the patient then was asymptomatic until he was readmitted June 30, 1944, because a sinus had formed. At this time the x-rays (Fig. 381) revealed an abscess cavity in the proximal femoral shaft. Diodrast injection of the sinus showed the tract leading to the abscess and a shorter branch posterior to the femur. The report on cultures was again hemolytic Staphylococcus aureus and very sensitive to penicillin. Therefore, the patient was placed on intensive penicillin therapy.

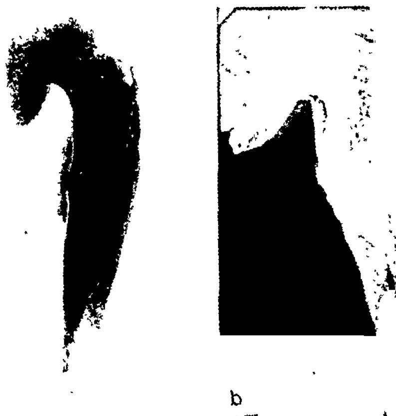


Fig. 383 (Case R. S.). *a* and *b*, Four years ten months following the second operation; patient asymptomatic with normal hip and knee motion; note regeneration of bone.

At operation, July 17, 1944, the large bone abscess cavity was cleaned out and the adjacent infected bone widely excised. (Fig. 382, *a* and *b*.) The wound healed by first intention and has remained healed and the patient asymptomatic up to his last visit May 6, 1949, four years and ten months after operation. At this time the x-rays (Fig. 383, *a* and *b*) still exhibit persistent sclerosis of the femur but no evidence of active bone infection.

SUMMARY AND CONCLUSIONS

With a combination of antibiotic therapy and adequate surgery the treatment of chronic suppurative osteomyelitis of the femur now offers a more hopeful prognosis.

Accurate delineation followed by complete excision of the sinus tracts and thereafter thorough removal of infected bone are the significant procedures at operation.

The details of and end results obtained in the management of 21 consecutive patients with chronic suppurative osteomyelitis of the femur are presented.

Since publication of this paper, 10 additional patients have been similarly treated. In all cases the wounds healed by primary intention. It should be noted also that all of the patients originally reported are well and their wounds have remained healed.

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THE BRAIN, SPINAL CORD AND NERVES

TREATMENT OF TUMORS OF THE PINEAL BODY

Experience in a Series of Twenty-Two Cases

GILBERT HORRAX

From the earliest days of operations for tumors of the brain up to the past twenty years, all attempts to extirpate solid growths which had apparently arisen from the pineal body (pinealomas, teratomas or gliomas) resulted in immediate operative fatality or the patient, if he chanced to survive the operation, died of a recurrence or of some other cause within a few months or, at most, a year or two. These early experiences were important, however, in demonstrating at least that it was possible to approach the pineal region by one or another operative procedure. In particular, the method devised by Brunner (cited by Rorschach[1]), and later modified and used by Dandy,[2] has been the procedure of choice for operations on pineal tumors by most neurosurgeons. That any operation designed for the removal of a pineal tumor is an extremely hazardous undertaking is well known to all neurosurgeons, even in the present era, when all modern adjuncts can be utilized. Cushing[3] made the statement in 1932 that he had "never succeeded in exposing a pineal tumor sufficiently well to justify an attempt to remove it." Dandy[4] in 1936, in reviewing his experiences with 10 cases of pineal tumor, reported 7 consecutive deaths during the period from 1921 to 1931 and stated that this "seemed almost to indicate the futility of further efforts." In 1 of the subsequent 3 cases which he reported in this paper[4] death occurred from recurrence of the tumor two and a half years later; in a second case death occurred three months after operation, and in the third the patient was well at the time of the report, but this was only four months after operation. Other individual reports of partial removal of tumors of the pineal body are those of Foerster,[5] Van Wagenen,[6] Harris and Cairns[7] and Horrax,[8] with survival periods up to fifteen months.

In 1943 Russell and Sachs[9] collected from the literature 58 cases of what they considered true pinealomas. In 32 of these cases operation had been performed for removal of the tumors, and in all but 3 cases the patients were known to be dead. Two of the living patients had only recently left the hospital at the time of the report, and the third patient was that of Harris and Cairns. This patient had shown signs of recurrence nine months after operation, but his condition had improved after roentgen treatment.*

In all probability, the first true pinealoma to be completely removed was that of a patient who was operated on by Peet in 1929 and reported by Kahn[10] in

Originally published in Archives of Neurology and Psychiatry, 64:227–242 (Aug.) 1950.

* This patient survived two years and seven months, and, although roentgen treatment apparently helped him for a while, he eventually died of a recurrence (personal communication from Dr. Cairns).

1937. At the time of the report, seven years after operation, the patient was living and well. He had been given high voltage roentgen radiation for a year after operation. In the same article Kahn also reported the case of a teratoma of the pineal region which he himself had removed, with the patient alive and well one year later. This patient survived ten years and died of a heart attack. He had been relatively well and had engaged in work (personal communication from Dr. Kahn). Another important case which has heretofore been overlooked in the literature is that described by Pratt and Brooks[11] in 1938. In this instance a solid tumor, measuring 3.5 by 3 by 2 cm., was apparently completely removed from the pineal region. The histologic description leaves little doubt that it was a true pinealoma. The patient received no roentgen therapy and was alive and well three and one-half years after operation.*

At a meeting of the Radiological Society of North America in December 1947, I summarized briefly my own experiences with pineal tumors, and this paper was published in February 1949.[12] In the present communication, an elaboration of that report, a more detailed account is given of several of the cases in which treatment was by radical removal of the tumor or a simple decompression followed by roentgen therapy.

The diagnosis of a pineal tumor was made in 22 cases occurring in my service at the Lahey Clinic between 1932 and 1948. Histologic verification of the tumor at operation or at necropsy was made in 13 cases. In most of the remaining 9 cases increased intracranial pressure and neurologic evidence of a pineal tumor were present, and in all the diagnosis was established beyond reasonable doubt by ventriculograms, which showed a sharply defined, rounded projection producing a filling defect in the posterior portion of the third ventricle.

HISTOLOGICALLY VERIFIED PINEAL TUMORS

In 10 of the 13 cases in which the tumor was verified histologically, a radical removal of the tumor was carried out, and in 3 the verification was made either by biopsy at operation or by necropsy. In 5 of the 10 cases in which the tumor was radically removed death occurred within a few days to three months after the operation. In 1 case the patient lived eight years after a primary incomplete removal of the tumor followed by high voltage roentgen therapy but died a few days after radical extirpation of the tumor. There were 2 cases of "ectopic" pinealomas in the chiasmal region. In 1 of these the patient was alive and well at the time of this report, seven and one-half years after removal of his tumor, but the case is not considered here, since he has never had evidence of a tumor in the pineal region. In the other case of an ectopic tumor the primary pineal tumor was removed by Dr. John Scarff, in New York, and the patient lived four years after removal of the tumor combined with high voltage roentgen therapy. He died a few months after the excision of his chiasmal tumor, in spite of further roentgen irradiation of this area. An encephalogram at this time showed no evidence of any remaining tumor in the pineal region.

* This patient was living and well until June 1946 (twelve years after operation) and had given birth to six children during this time. She died in March 1948 (fourteen years after operation) without evidence of recurrence of the tumor (personal communication from Dr. Pratt).

The 3 patients whose tumors were verified either by necropsy or by biopsy all died after operation. In the remaining 2 cases in which the pineal tumors were apparently completely removed the patients are in excellent health and have been usefully employed twelve and five and one-half years, respectively. Brief summaries of these 2 cases follow. Case 1 represents the longest survival period so far recorded after radical, and apparently complete, removal of a pinealoma.

CASE 1. B. P., an unmarried white woman aged 35, was referred by Dr. J. J. Skirball, of Boston, and was admitted to the New England Deaconess Hospital on Oct. 22, 1937. She had had severe frontal headaches for three months, and had complained of dizziness and double vision for ten days prior to admission. Neurologic examination disclosed 4 to 5 D. of papilledema, nonpersistent upward and lateral nystagmus and generally overactive reflexes. Her pupils reacted normally, and the other ocular movements were normal.

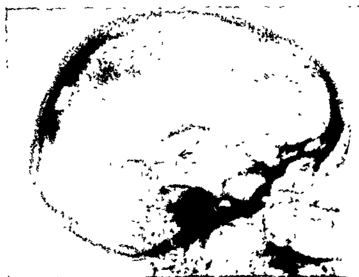


FIG 384 (Case 1). Lateral ventriculogram showing pronounced dilatation of the lateral ventricles and the rounded projection (arrow) in the posterior portion of the third ventricle.

On October 27 ventriculographic examination showed that the ventricles were greatly dilated (120 cc. of fluid was removed), and subsequent roentgenograms showed a sharply defined, rounded projection into the posterior portion of the third ventricle (Fig. 384).

Operation.—Immediately after the ventriculographic procedure an osteoplastic flap was turned down in the parieto-occipital region, and the right occipital pole was resected. The splenium of the corpus callosum was then incised, and beneath it there presented a tumor which spread the internal cerebral veins (lesser veins of Galen) apart. The posterior portion of the falx was resected back to the tentorium to attain better exposure of the tumor.

An attempt was first made to remove the growth intact, but this was not feasible. Its capsule was therefore incised, and the contents were removed by spoons and suction. The capsule was then withdrawn from the surrounding structures, leaving a smooth surface along its bed on the corpora quadrigemina. The tumor was soft and highly vascular, but removal was apparently complete.

The patient's convalescence was stormy. Ventricular taps were made twice daily and sometimes oftener. Eight days after operation the bone flap was reelevated because a postoperative clot was suspected, but none was found.

Progress Notes. November 9: The patient was conscious and rational, but concentration and memory were poor. Her pupils were dilated and reacted poorly to light and not at all in accommodation. There was paralysis of the left abducens nerve. Conjugate movements of the eyeballs were good toward the right and downward, but the eyeballs *could not be elevated above the horizontal plane, nor could they be turned to the left* beyond the median line (Fig. 385). Convergence was nil. There were complete left homonymous hemianopsia and left partial hemiplegia, the latter showing improvement, although it had been complete immediately after operation. The elevation of the optic disks had subsided to between 2 and 3 D.



Fig. 385 (Case 1). Conjugate deviation of the eyes to the right and somewhat downward, which was present for several weeks after operation.

Jan. 26, 1938: The patient was discharged on this date, having made excellent general progress since the time of the previous notation. She had been up and about the ward for two or three weeks but was not yet fully oriented, with some difficulty in memory for recent events only. Her pupils were moderately dilated and reacted well in accommodation and fairly well to light. All extraocular movements, including upward gaze, were now completely normal. The optic disks showed no elevation. There were astereognosis of the left hand and moderate weakness of the left arm and leg, but no loss of sensation to pain or temperature stimuli. The left homonymous hemianopsia, of course, remained complete.

April 4 to 9, inclusive: In this period she was given a series of high voltage roentgen treatments.

Oct. 26, 1938. She had begun part time in usual work as a stenographer on May 15, 1938, and at the present date, one year after operation, she was doing full time work, being able to take dictation and do her typing with both hands without difficulty. She had become accustomed to the left homonymous hemianopsia.

Last Report (June 22, 1949). During the postoperative period of eleven years and eight months, she had remained in excellent general health and had been at her regular

work as a secretary. Her fundi and ocular movements were normal. Both pupils reacted to light, but the left very faintly. The reaction in accommodation was normal. The left homonymous hemianopsia was complete, as before.

Pathologic Report. The tumor was moderately cellular and fairly uniform. It was composed of epithelium-like cells, resembling parenchyma cells of the pineal body.

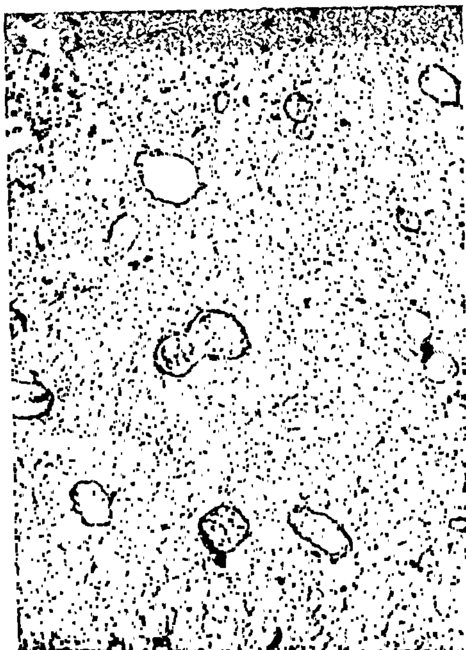
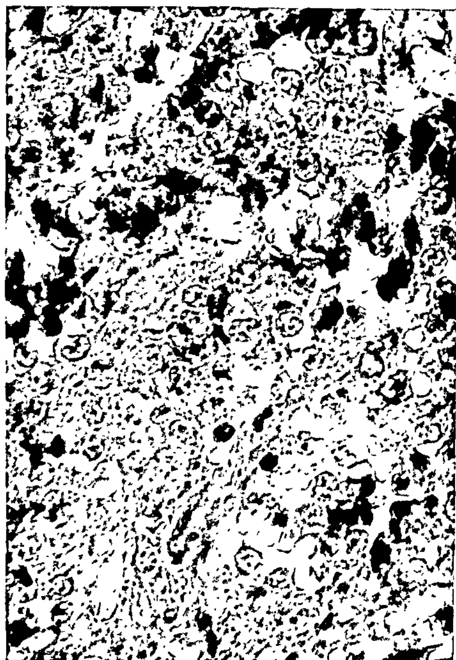


Fig. 386 (Case 1). Photomicrograph of tumor (× 244) showing the general character and uniformity of the undifferentiated cells. Note the closely packed rows, with a tendency to mosaic pattern. Hematoxylin and eosin stain.

These were usually arranged in closely packed rows along strands of delicate vascular stroma (Fig. 386). The cytoplasm of the cells was relatively scant and showed no well defined glial process. The nuclei were round or oval and vesicular with indistinct nucleoli (Fig. 387). Mitotic figures were rare. Small lymphocyte-like cells were present but infrequent. The histologic diagnosis was pinealoma.

Comment. The feature of greatest neurological interest in this case was the absence before operation of the ocular phenomena which are characteristic of tumors in this locality; this is the more significant since the tumor was large, probably at least 30 to 35 gm. in weight, although this could only be estimated,



[illegible] showing more [illegible] small,

the greater portion of the growth having been lost through suction. The tumor, however, was soft and thus may not have exerted much pressure on the brain stem. It is of interest, also, that the patient rapidly became used to the complete left homonymous hemianopsia and was able to resume her secretarial work about seven months after her serious operation.

Now, after twelve years, it can almost certainly be assumed that she is permanently cured. Her case can thus be classed with that of the patient operated on by Peet and reported by Kahn as being well seven years after operation, and the case of Pratt and Brooks, in which no evidence of recurrence was present after fourteen years, as stated previously.

Case 2. M. J. K., an unmarried school teacher aged 25, was referred by Dr. C. S. Andrews, of Boston, and was admitted to the New England Deaconess Hospital on Jan. 25, 1944.

History. Her menstrual periods began at the age of 13 years and occurred regularly at six week intervals until September 1942, when they became irregular, with intervals



Fig. 388 (Case 2). Lateral ventriculogram showing extreme dilatation of the lateral ventricles, as well as lack of filling in the posterior portion of the dilated third ventricle due to rounded projection of tumor (arrows).

up to two months. Her last period had been on Aug. 18, 1943, five months before her admission. Since November 1943 she had had four episodes of severe headache and vomiting, each episode lasting about twenty-four hours. She had also become increasingly unsteady in walking during this period Some difficulty in vision had been noted during the month prior to admission.

Neurologic Examination. Her pupils were equal and reacted normally, and all extraocular mov[illegible] of her right arm and a strongly positive Romberg sign. Her gait was ataxic with a tendency to fall to the right.

Operation (*Jan. 27, 1944*). A ventriculogram, made on this date, showed a dilated ventricular system, with a questionable filling defect in the posterior portion of the third ventricle (Fig. 388). Since the ventriculogram was thought to be inconclusive and the cerebellar symptoms were outspoken, a cerebellar exploration was carried out, but no tumor was disclosed. A catheter inserted upward through the fourth ventricle met with obstruction at a distance of 4 cm.

The cerebellar wound was closed, and immediately afterward an osteoplastic flap was turned down in the right occipitoparietal area. After removal of the right occipital

lobe, the tentorium was incised down to the incisura and the falx incised a short distance upward. The splenium of the corpus callosum was divided and the tumor exposed in the posterior end of the third ventricle. The growth was grayish brown and had a fairly firm capsule. The right internal cerebral vein was divided to gain better

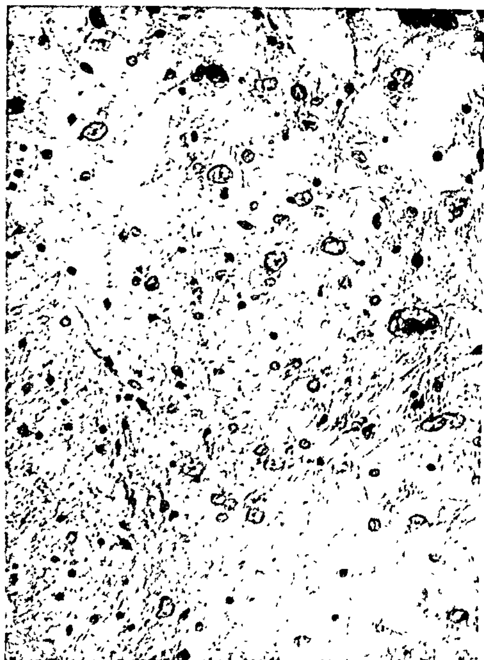


Fig 389 (Case 2). Photomicrograph of tumor (× 244) showing general characteristics of the sparsely cellular tumor with loosely reticular matrix. Hematoxylin and eosin stain.

exposure, after which the capsule of the tumor was incised and its contents were removed by spoons and suction The remaining capsule and tumor fragments were then excised. Closure was carried out with drainage to the tumor cavity.

Convalescence was stormy. On February 2 the bone flap was reelevated, since the patient had become drowsy, but no clot was found. On February 8 a catheter was inserted into the left lateral ventricle for purposes of decompression and left in for forty-eight hours. On February 15 a decompression was carried out in the right subtemporal

region and a catheter left in the right lateral ventricle for forty-eight hours. After the last procedure she made a satisfactory, but very gradual, convalescence.

Roentgen Therapy. Between February 18 and March 6 she was given a series of high voltage roentgen treatments, a total of 2,100 r being delivered through each of two ports to the pineal region.

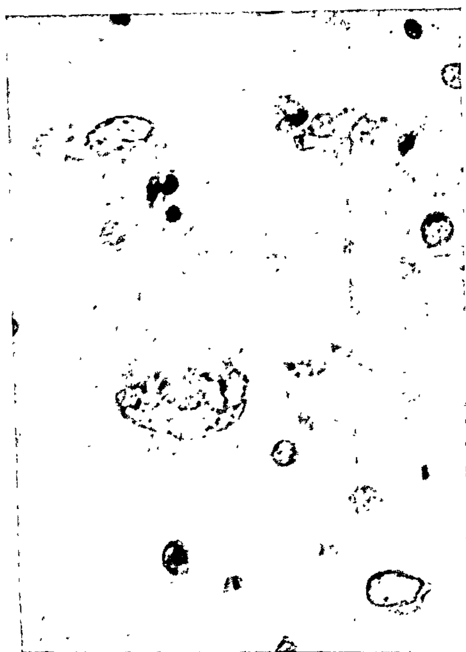


FIG. 390 (Case 2). Photomicrograph of tumor (high power), giving a detail of pleomorphic cells with large vesicular nuclei. Note the large multinucleate cell.

Subsequent Course. She was discharged to her home on April 5, and at that time she was alert, talking, eating well and moving both arms and both legs well.

May 9, 1944: On this date she was sitting up and walking a little. She was clear mentally. There was slight weakness of the left arm and leg.

Oct. 1, 1945: On this date, one year and eight months after operation, her condition was practically normal except for the left homonymous hemianopsia. There was no

weakness or sensory deficit on the left side. She was normally active physically and had resumed her teaching to a limited extent.

July 19, 1949: On this date, five and one-half years after operation, the patient was well and engaged in her usual teaching position.

Pathologic Report. The tumor was sparsely cellular and composed for the most part of moderately pleomorphic cells with ill defined cytoplasm. The matrix of the tumor was loosely reticular and fibrillar, derived in part from the tumor cells. The nuclei of the cells were often large, pale and vesicular and sometimes contained enormous nucleoli. Multinucleate cells were present. Scattered among the large cells were a few small, poorly differentiated glial cells and cells resembling lymphocytes. Mitotic figures were rare (Figs. 389 and 390). The histologic diagnosis was pinealoma.

Comment. This case represents the only other instance in my series of a long survival (five and one-half years) after the radical removal of a pinealoma in the usual situation. I have had a case of an ectopic pinealoma in the chiasmal region in which the tumor was removed in 1942 and the patient has been well to date (seven years after operation), but this case need not be considered in the present connection and has been reported elsewhere.[13]

The circumstance to be emphasized in the case just cited is the impression at the time the operation was begun that the tumor was in the cerebellum because of inconclusive evidence from the ventriculogram that the growth was farther forward. This error has occurred three times in the 22 cases in this series, and from a review of the records of these 3 cases it is evident that the cerebellar symptoms were outspoken and that in 2 cases the ventricular picture was not entirely clear, so that in 1 case a second ventriculogram was made after his cerebellar exploration. In the third case the projection of the tumor in the posterior portion of the third ventricle was misinterpreted.

TUMORS "VERIFIED" BY VENTRICULOGRAPHY

In 9 cases in this series a tumor projecting into the posterior portion of the third ventricle, associated with dilated lateral ventricles, was demonstrated by ventriculograms. In 5 of the 9 cases confirmatory neurologic data of a tumor in this region were present, i. e., Argyll Robertson pupils and loss of conjugate movements of the eyeballs above the horizontal plane. This combination of evidence is practically pathognomonic. In all but 1 case treatment was by decompression in the right subtemporal region followed by high voltage roentgen irradiation of the region of the presumed pineal tumor. In 3 cases death occurred one to two years after operation. In the other 6 cases the patients are well and leading active lives in their usual occupations, from two to seventeen years after decompression and roentgen therapy. The patient who was given roentgen therapy without decompression had an acute upset during the treatment, which had to be stopped temporarily, but the roentgen therapy was eventually finished, and he has been perfectly well for ten years.

Several of these cases have been reported elsewhere in different connections,[14a] but 2 typical instances may be given here.

CASE 3. R. M., a man aged 31, was first admitted to the Peter Bent Brigham Hospital on Oct. 24, 1932. His illness consisted in headaches, vomiting and blurring of vision for six weeks. He had likewise had diplopia and dizziness for four weeks. Neu-

rologic examination showed unequal pupils, which reacted sluggishly to light and in accommodation. Examination of the fundi revealed bilateral choked disks, with an elevation of 3 to 4 D.

Operative and Roentgen Therapy. A ventriculogram, taken on October 26, showed considerable dilatation of the lateral ventricles. The posterior portion of the third ventricle was occluded by a rounded projection, characteristic of a tumor in this region (Fig. 391). For this reason, a craniotomy combined with a decompression in the right parieto-occipital region was performed on October 28. After this procedure, the patient received five series of roentgen treatments by Dr. M. C. Sosman, who furnished the details of treatment and the roentgenogram. Each series consisted of four applications of 750 r each to either side of the head, directed toward the pineal region. The patient



Fig. 391 (Case 3). Lateral ventriculogram showing rounded tumor projection in the posterior portion of the third ventricle (arrow).

was discharged on November 14, at which time the choking of the disks had subsided and he was free of headaches and other preoperative symptoms.

He remained well until December 1941, nine years after his operation, at which time diabetes insipidus developed, with an intake and output of approximately 3,500 cc. of fluid per twenty-four hours. These symptoms persisted in spite of further roentgen therapy directed toward the suprasellar and pineal regions. He has been followed at intervals up to the present time.

Report. In July 1949, seventeen years since his operation and original roentgen treatment, the patient was in excellent health except for his polyuria and polydipsia, and was active in his regular occupation as a salesman.

Comment. This case, that of a patient who remained in useful life after decompression and roentgen therapy for a presumed tumor of the pineal body, represents the longest follow-up record in this series. This case is the only one thus far in which diabetes insipidus developed after treatment for tumor of the pineal body, and this in spite of the fact that the patient had considerably more radiation immediately after his decompression than have subsequent patients. As I said, in commenting on his case in a previous communication[14b]: "It is pos-

sible that the water imbalance may persist because partial interruption of the nerve tract from hypothalamus to pituitary is permanent even though the tumor cells originally causing this interruption have been destroyed by the roentgen rays."

A combined craniotomy and decompression were done in this case because at the time (1932) I anticipated having to make a transventricular approach to the tumor subsequently and the hope was that the decompression would allow the ventricle on the right side to dilate further and thus facilitate the transventricular operation. Fortunately, the latter has never been necessary.

The following case represents another instance in which, because of an inconclusive ventriculogram, a preliminary cerebellar exploration was made, without encountering a lesion.

CASE 4. V. N., a youth aged 16, was referred by Dr. A. J. Bedell, of Albany, N. Y., and was admitted to the New England Deaconess Hospital on May 13, 1940. For six



Fig 392 (Case 4) Lateral ventriculogram showing tumor projection into the posterior portion of the third ventricle (arrow)

months prior to admission he had had severe headaches, nausea and vomiting, together with progressive failure of vision. Diplopia had been present at times. Neurologic examination disclosed bilateral papilledema of 6 D., bilateral paralysis of the abducens nerve and limitation of upward gaze. His pupils reacted slightly to light but well in accommodation. He also showed an unsustained nystagmus, hypotonia of the arms and slight ataxia in the finger to nose test.

Operations and Result. On May 15 a ventriculographic study was performed, but filling was not completely satisfactory; as nearly as could be told a suboccipital lesion was probable. Therefore, on the same day a cerebellar exploration was carried out, but no abnormality was found. On May 17 the ventriculographic examination was repeated, and this time an unmistakable filling defect was observed in the posterior portion of the third ventricle (Fig 392). A decompression was performed in the right subtemporal area on the same day, and he was given the usual course of roentgen therapy to the pineal region on recovery from this procedure. When he was discharged, on June 10, his decompression area was soft, and the choking of the disks had receded to

an elevation of 1 D. There was likewise no limitation of upward gaze, but his pupils still reacted poorly to light.

Final Report. The patient was seen at yearly intervals through 1946, and his general condition remained excellent. He finished school and then started in a regular occupation, which he has continued without interruption. His pupils have never regained their reaction to light, but ocular movements are normal.

A letter on June 25, 1949, nine years after operation, stated that he was in his usual good health (Fig. 393).

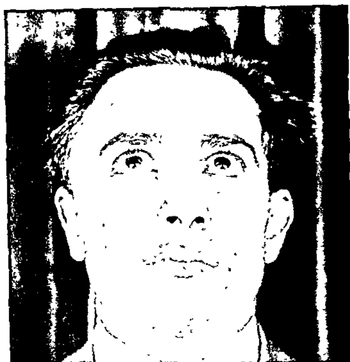


Fig 393 (Case 4). Photograph of patient two years after operation showing unrestricted upward movement of the eyeballs.

Comment. At the time this patient was subjected to his first ventriculographic examination, he had a serious respiratory upset, with temporary cessation of breathing, so that the filling was not as good as usual and the subsequent films were interpreted as indicating a lesion of the posterior fossa Such a lesion was thought to be more likely than a tumor of the third ventricle as a cause of the respiratory difficulty. It is probable that the drainage of the ventricles by catheter for two days after the first procedure was a life-saving measure.

The other noteworthy point in this patient's record was the rapid subsidence of his pressure symptoms and papilledema, as well as of the bulging and tense area of decompression following the latter operation and the roentgen therapy. Although this was likewise the result in Case 3, there have been other instances in which pressure signs and symptoms did not subside until a second course of roentgen therapy, seven to eight weeks after operation.

SUMMARY

The operative and roentgenologic treatment is reviewed in a personal series of 22 cases in which the diagnosis of pineal tumor was made. In 13 cases the diagnosis was verified histologically, and in 9 it was made almost certain by

localizing neurologic evidence combined with a characteristic ventriculographic picture showing the tumor projection in the posterior portion of the third ventricle.

In 2 cases of histologically verified pinealomas in which the tumors were apparently completely removed the patients are alive and well twelve and five and one-half years after operation, respectively. In 1 case of an ectopic pinealoma in the suprasellar region, histologically verified, the patient has thus far remained well, seven and one-half years after the removal of this growth.

In 6 cases the patients are alive and well (except for diabetes insipidus in 2 cases) from two to seventeen years after decompression and roentgen therapy. In these cases the diagnosis was made neurologically and ventriculographically.

In 1 case the patient remains well (except for diabetes insipidus) ten years after roentgen therapy without decompression.

The importance and far greater safety of the conservative treatment of these tumors by decompression and roentgen therapy rather than by a radical extirpation of the tumor are once more emphasized.

I am greatly indebted to Dr. S. J. Hicks, of the pathological department of the New England Deaconess Hospital, for his description and interpretation of the histologic sections of the tumors.

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THE END RESULTS OF COMPLETE VERSUS INTRACAPSULAR REMOVAL OF ACOUSTIC TUMORS

GILBERT HORRAX AND JAMES L. POPPEN

The so-called acoustic tumors are the common type of intracranial new growths situated in the cerebellopontile angle. Although they are benign, encapsulated, noninvasive lesions, their removal in the early days of neurosurgery was attended with such a high mortality (75 to 85 per cent) as to be prohibitive, and even then it is doubtful whether complete removals with useful survival of the patients were ever accomplished.

In 1917, therefore, Harvey Cushing[2] introduced the method of what he termed the "intracapsular extirpation" of these tumors. This meant that after incising the capsule, the contents of the growth within were more or less completely taken out with a blunt curet combined with suction. In this way it was inevitable that some portions of the tumor would remain inside the capsule, as the latter was left *in situ*, and recurrence took place at varying intervals, many within two to five years following the operation, although a fair number of patients lived for much longer periods. However, the intracapsular operation constituted a great step forward, since, for the first time, it offered patients with acoustic tumors a good chance at least of coming through the operative procedure. The immediate mortality was reduced, at least in Cushing's hands, from prohibitive figures down to 20 per cent at first, and later to less than 10 per cent.

On the other hand, it became obvious that the intracapsular removal was far from ideal, both because of almost certain recurrence and because the five-year mortality after this procedure was exceedingly high—56 per cent in Cushing's series, from figures given by Eisenhardt[7] in 1935. For this reason Dandy[3] made a preliminary report in 1922 of an operation for the complete removal of acoustic tumors, followed in 1925[4] by recording 5 such complete extirpations without mortality. In 1934[5] he introduced an important technical advance in the unilateral approach through a relatively small bony opening instead of the wide bilateral exposure used hitherto.

Since these early articles there have been surprisingly few reports by neurosurgeons concerning the end results of operations for acoustic tumors by either of the methods mentioned. In 1934 Olivecrona[10] reported 31 cases in which complete extirpation had been performed with a 19.4 per cent mortality. He stated that the end results and useful survival in this group were far better than in his previous series of intracapsular extirpations.

In 1939 the present authors reported[8] a series of 35 patients with acoustic tumors on whom they had operated during the previous seven years. Seven of those patients had intracapsular removals, and although the operative mortality

Originally published in Annals of Surgery, 130:567–573 (Sept.) 1949. J. B. Lippincott Co., publishers.

was not great, all but one of these patients died subsequently. Nine other patients had one or more previous attempts at removal of their tumors elsewhere, and although we were eventually able to extirpate their growths completely they need not be considered in the present connection, since the difficulties and hazards in this group are exceedingly great. The remaining 19 patients had not been operated on previously and a complete removal of their tumors was accomplished. The operative mortality in this latter group was 10.5 per cent, and it was stated that, aside from the 2 postoperative deaths and 4 others who showed considerable disability, the remainder (68 per cent) "were able to get about perfectly well by themselves and, for the most part, to resume their former occupations."

In 1942 Nielsen[9] made a careful study of Olivecrona's large series of 130 acoustic tumor patients operated on between the years 1930 and 1939. Twenty-eight of these patients had intracapsular extirpations of their tumors and Nielsen also gave mortality figures for 34 patients with this type of operation performed previously by Olivecrona, making a total of 62 intracapsular removals. There were likewise 75 patients who had had their tumors completely taken out. Without going into the details of Nielsen's statistics it was pointed out that the immediate operative mortality from intracapsular removal was between 27 and 28 per cent and that within five years the death of 16 more patients had occurred, making the total five year mortality for this group roughly 56 per cent. On the other hand, the operative mortality in the completely removed group was 18.7 per cent, and although 4 of these patients died subsequently, in only 1 was there the possibility that death was due to tumor recurrence.

In regard to useful survival, that is, either full or somewhat diminished earning capacity, Nielsen stated that 75 per cent of the patients having intracapsular extirpations came into this category. This figure refers obviously only to those patients who survived the operation and the subsequent five-year interval, since only 27 patients, or roughly 44 per cent of the original 62 in this group, survived. As will be shown later, we feel that the only real way of determining correct end results is to base the percentage of useful survival on the total number of patients operated upon. If such a comparison is made, the 75 per cent, or 21 of the 27 survivors, would represent 33.8 per cent of the total 62 patients with intracapsular removals who were leading useful lives.

In the group of complete extirpations Nielsen has again followed the same method of basing the percentage of patients living useful lives on the number surviving the operation and the five-year interval. His figure for this group by this method would be 80.4 per cent, but if one bases the percentage on the total number of patients operated upon, namely 75, it is found that roughly 60 per cent of patients who had complete removal of their tumors were living useful lives at the time they were studied. As can be seen, this figure is nearly twice the percentage of those in the intracapsular group.

In 1943 Dandy* summarized his experiences with 46 patients who had complete removal of their acoustic tumors. There were 5 deaths in this series, an operative mortality of 10.87 per cent. In connection with the end results he

* Article was apparently not published. Manuscript was sent to one of us (G. H.) by the author and the figures given are taken from that.

stated that 2 patients died within one year after leaving the hospital. Concerning useful survival the following statement was made: "So far as I know all the remaining cases are living and well. With few exceptions all are active, and many of them are carrying on their former work in full capacity. Perhaps half a dozen have some degree of uncertainty in walking and have slight ataxia." It is impossible to get any useful numerical percentage as to satisfactory survival in this series, especially since the author includes "several" small tumors which "were encountered when operating for trigeminal neuralgia by the cerebellar route." These would not be considered as the usual type of relatively large tumors which most authors have dealt with in tabulating both their mortality as well as their end results. However, it is safe to assume that Dandy's figures would at least be as good as others who have made similar studies.

Olivecrona's last report in 1948[11] is concerned with 250 operations for acoustic tumors. Of these, 185 had complete extirpations, and in 34 the tumors were subtotally removed. In only 26 was the intracapsular method employed. The operative mortality for the entire group was 23.6 per cent, and for the 185 from whom the tumor was completely removed was 24.3 per cent. Ten of these latter died from one to fifteen years after leaving the hospital. Because of the impossibility of anything like complete follow-up figures in Olivecrona's series (since many of his patients were in European countries during the war), only rough estimates of the percentage of patients living useful lives can be made. From his figures there were 118 patients having complete tumor removals who had full or somewhat diminished earning capacity. This would be 63.2 per cent of the original 185 patients operated upon by this method, but would represent 84.2 per cent of the 140 who survived the operation and left the hospital. Twenty-six of Olivecrona's patients had the intracapsular operation. Seven of these died postoperatively and seven others subsequently, thus making the eventual mortality 53.8 per cent. Of the remaining 12 patients, 9 or 75 per cent were in useful life, but based on the original 26 patients this represents only 34.6 per cent.

To summarize the data as given by Olivecrona and by Nielsen from Olivecrona's clinic one may say that the five-year mortality for complete tumor removals (including the operative mortality) would be roughly 25 per cent, whereas with the intracapsular operation for a like period the mortality would be about 54 per cent These figures in themselves are significant, but even more so are those for patients living useful lives, since about 60 per cent of those whose tumors were entirely removed came into this category but this was true of only some 34 per cent of the patients who had had intracapsular extirpations. These percentages are based on the number of patients living usefully as compared with the total number of patients operated upon.

Aside from the figures from the intracapsular series of Olivecrona, as given by himself and Nielsen, the only chance of making a comparison of this method with that of complete tumor removal is through a study of Cushing's end results as given by several of his pupils, since in practically all instances Cushing's patients were operated upon by the intracapsular procedure. It is because some doubt has existed as to the relative merits of the intracapsular versus the complete extirpation of these tumors that the present study has been undertaken.

was not great, all but one of these patients died subsequently. Nine other patients had one or more previous attempts at removal of their tumors elsewhere, and although we were eventually able to extirpate their growths completely they need not be considered in the present connection, since the difficulties and hazards in this group are exceedingly great. The remaining 19 patients had not been operated on previously and a complete removal of their tumors was accomplished. The operative mortality in this latter group was 10.5 per cent, and it was stated that, aside from the 2 postoperative deaths and 4 others who showed considerable disability, the remainder (68 per cent) "were able to get about perfectly well by themselves and, for the most part, to resume their former occupations."

In 1942 Nielsen[9] made a careful study of Olivecrona's large series of 130 acoustic tumor patients operated on between the years 1930 and 1939. Twenty-eight of these patients had intracapsular extirpations of their tumors and Nielsen also gave mortality figures for 34 patients with this type of operation performed previously by Olivecrona, making a total of 62 intracapsular removals. There were likewise 75 patients who had had their tumors completely taken out. Without going into the details of Nielsen's statistics it was pointed out that the immediate operative mortality from intracapsular removal was between 27 and 28 per cent and that within five years the death of 16 more patients had occurred, making the total five year mortality for this group roughly 56 per cent. On the other hand, the operative mortality in the completely removed group was 18.7 per cent, and although 4 of these patients died subsequently, in only 1 was there the possibility that death was due to tumor recurrence.

In regard to useful survival, that is, either full or somewhat diminished earning capacity, Nielsen stated that 75 per cent of the patients having intracapsular extirpations came into this category. This figure refers obviously only to those patients who survived the operation and the subsequent five-year interval, since only 27 patients, or roughly 44 per cent of the original 62 in this group, survived. As will be shown later, we feel that the only real way of determining correct end results is to base the percentage of useful survival on the total number of patients operated upon. If such a comparison is made, the 75 per cent, or 21 of the 27 survivors, would represent 33.8 per cent of the total 62 patients with intracapsular removals who were leading useful lives.

In the group of complete extirpations Nielsen has again followed the same method of basing the percentage of patients living useful lives on the number surviving the operation and the five-year interval. His figure for this group by this method would be 80.4 per cent, but if one bases the percentage on the total number of patients operated upon, namely 75, it is found that roughly 60 per cent of patients who had complete removal of their tumors were living useful lives at the time they were studied. As can be seen, this figure is nearly twice the percentage of those in the intracapsular group.

In 1943 Dandy* summarized his experiences with 46 patients who had complete removal of their acoustic tumors. There were 5 deaths in this series, an operative mortality of 10.87 per cent. In connection with the end results he

* Article was apparently not published. Manuscript was sent to one of us (G. H.) by the author and the figures given are taken from that.

stated that 2 patients died within one year after leaving the hospital. Concerning useful survival the following statement was made: "So far as I know all the remaining cases are living and well. With few exceptions all are active, and many of them are carrying on their former work in full capacity. Perhaps half a dozen have some degree of uncertainty in walking and have slight ataxia." It is impossible to get any useful numerical percentage as to satisfactory survival in this series, especially since the author includes "several" small tumors which "were encountered when operating for trigeminal neuralgia by the cerebellar route." These would not be considered as the usual type of relatively large tumors which most authors have dealt with in tabulating both their mortality as well as their end results. However, it is safe to assume that Dandy's figures would at least be as good as others who have made similar studies.

Olivecrona's last report in 1948[11] is concerned with 250 operations for acoustic tumors. Of these, 185 had complete extirpations, and in 34 the tumors were subtotally removed. In only 26 was the intracapsular method employed. The operative mortality for the entire group was 23.6 per cent, and for the 185 from whom the tumor was completely removed was 24.3 per cent. Ten of these latter died from one to fifteen years after leaving the hospital. Because of the impossibility of anything like complete follow-up figures in Olivecrona's series (since many of his patients were in European countries during the war), only rough estimates of the percentage of patients living useful lives can be made. From his figures there were 118 patients having complete tumor removals who had full or somewhat diminished earning capacity. This would be 63.2 per cent of the original 185 patients operated upon by this method, but would represent 84.2 per cent of the 140 who survived the operation and left the hospital. Twenty-six of Olivecrona's patients had the intracapsular operation. Seven of these died postoperatively and seven others subsequently, thus making the eventual mortality 53.8 per cent. Of the remaining 12 patients, 9 or 75 per cent were in useful life, but based on the original 26 patients this represents only 34.6 per cent.

To summarize the data as given by Olivecrona and by Nielsen from Olivecrona's clinic one may say that the five-year mortality for complete tumor removals (including the operative mortality) would be roughly 25 per cent, whereas with the intracapsular operation for a like period the mortality would be about 54 per cent. These figures in themselves are significant, but even more so are those for patients living useful lives, since about 60 per cent of those whose tumors were entirely removed came into this category but this was true of only some 34 per cent of the patients who had had intracapsular extirpations. These percentages are based on the number of patients living usefully as compared with the total number of patients operated upon.

Aside from the figures from the intracapsular series of Olivecrona, as given by himself and Nielsen, the only chance of making a comparison of this method with that of complete tumor removal is through a study of Cushing's end results as given by several of his pupils, since in practically all instances Cushing's patients were operated upon by the intracapsular procedure. It is because some doubt has existed as to the relative merits of the intracapsular versus the complete extirpation of these tumors that the present study has been undertaken.

There are three principal questions to be answered. First, what is the immediate operative mortality in the two groups; second, what is the mortality after an interval of five years, and third, most important of all, what is the percentage of useful survival of the patients operated upon by the two methods?

In respect to the last question, it was mentioned previously that heretofore the percentage of patients in useful life has been based frequently on the number of those who survived the operation as well as a postoperative period, usually of five years. This method, however, would be quite unfair in the present comparison for the reason, as will be pointed out, that whereas the actual operative mortality may be more or less comparable in the two groups, nevertheless, during the next five years a very large number of patients in the intracapsular group will have died, but only an insignificant number of those whose tumors were totally removed. In other words, let us say that there were 100 patients who had been operated upon by the intracapsular method, and at the end of five years, 50 of these patients had died either postoperatively or within this interval. If 25, or half of these survivors, were living useful lives the percentage of useful life based only on the number of survivors would be 50 per cent, whereas if based on the original 100, it would be 25 per cent.

On the other hand, if 100 patients had had their tumors completely removed and only 20 of these had died postoperatively or during the five-year interval with 40, or half the remainder, in useful life, the incidence of useful living based only on the number of survivors would again be 50 per cent even though there were 40 such patients by this method against 25 by the intracapsular procedure, but based on the original 100 patients the figure would be 40 per cent against 25 per cent by the incomplete method. The real question to be decided is, given a certain number of patients having acoustic tumors, what percentage of that original number may be expected to have survived each type of operation and a five-year interval and to be living useful lives at the end of that time or longer?

RESULTS OF INTRACAPSULAR EXTIRPATION (CUSHING'S SERIES)

The mortality figures here given are taken from Eisenhardt's follow-up report in 1935. The figures for estimated useful survival were derived from reports made on a consecutive three-year series of Cushing's cases by three of his pupils, Van Wagenen,[12] Cairns[1] and Davidoff.[6]

Total patients operated upon (circa 1906–1932)........ .	176	
Total patients living five years or more.........	77	
Five-year mortality (99 cases including postoperative deaths)..		56.2 per cent
Useful survival of the total 176 cases.......	44 or 25	per cent
Useful survival of the 77 five-year survivors......	44 or 57.1	per cent

In reviewing the above statistics it must be remembered that many of Cushing's patients were operated upon in the very early days of neurosurgery when the modern adjuncts of electrosurgery and strong suction and antibiotics were not available, but even so his actual operative mortality was exceedingly low, and was reduced in his last 50 cases to 4 per cent. However, the really significant figure is the one which shows that of the original 176 patients only 77 had

survived the operation and the subsequent five-year period. So far as the useful survival of the patients in Cushing's series is concerned the figures are admittedly estimated, but these estimates were taken from follow-up studies by his pupils who were at some pains to get an accurate idea of what the patients' disabilities were, if any. To the best of their knowledge about one quarter (25 per cent) of the 40 patients who were followed were living useful lives, but in view of the statistics given by Nielsen and Olivecrona for the intracapsular operation it is altogether probable that this figure should be raised to 33 to 35 per cent, inasmuch as it is undoubtedly true that Cushing's results by this procedure were at least as good if not better than others using this method. Even so, such a percentage falls far short of that for patients who have had their tumors completely removed.

Since no definite estimate of useful survival can be derived from Dandy's publications, and since it was impossible for Olivecrona to follow a considerable number of his patients on account of war conditions, we have attempted to make a comparison of the intracapsular results of Cushing with our own series of total tumor extirpations. We have considered that patients were living useful lives if they had returned to their original occupation or something comparable to it, or, in the case of women, if they had resumed their usual household duties. Certain older patients who came within the retiring age were considered in useful life of they had no great physical disabilities. However, if patients had handicaps such as marked ataxia or weakness, or if they were blind, even though their vision had been lost before the operation, they were not put into the useful category.

At this point the question of facial paralysis comes up. With but few exceptions, possibly four in our experience, this is almost inevitable in doing a complete extirpation of acoustic neuromas of any considerable size. In the majority of cases the enlarged internal auditory meatus is filled with tumor cells, and since these must be curetted out, the facial nerve can only in rare instances be spared. This matter has always been discussed with patients, and in all but one case they have preferred this to a recurrence of their growth. The appearance of the face can be helped considerably by a subsequent anastomosis with either the hypoglossal or the spinal accessory nerve. Only when the facial paralysis prevented them from doing some gainful work has this feature been considered as depriving them of useful life.

Since 1934, when we began to do complete extirpation of acoustic tumors routinely, there have been 83 patients so operated upon. However, as mentioned earlier, 9 of these patients had been operated upon elsewhere previously with incomplete tumor removal, and these need not be considered here as they present very great difficulties and hazards. Likewise, 2 patients having bilateral tumors have been excluded for obvious reasons. There were, therefore, 72 patients who had not been operated upon previously and whose tumors were totally extirpated. There were 8 deaths in this group, or an operative mortality of 11.1 per cent. Even though none of these patients have as yet died since leaving the hospital, nevertheless in order to get a strict comparison with Cushing's as well as with other series, we shall consider only the 47 patients operated

upon from 1934 through 1944, so that a five-year or more follow-up period may be obtained. These data may be summarized as follows.

Patients previously unoperated upon who have had complete removal of their acoustic tumors

Total patients operated upon (1934–1944)..........	47	
Total patients living five years or more...............	41	
Five-year mortality (same as operative mortality).......	6	12.7 per cent
Useful survival of the total 47 cases...................	31	65.9 per cent
Useful survival of the 41 survivors....................	31	75.6 per cent

DISCUSSION

From the data which we have been able to gather through a study of our own series and the other available sources there would seem to be little to say *in regard to the merits of the two methods here compared since the figures* speak for themselves. In other words, if one compares the above figures or the ones given previously for total tumor removals with the results following the intracapsular operation, it will be seen that the five-year mortality (including postoperative deaths) for patients having complete removals runs from about 12 to 25 per cent, while for the intracapsular it is 53 to 56 per cent. Furthermore, of the original number of patients operated upon, some 60 to 65 per cent with complete tumor removal will be in useful life against possibly 35 per cent of *those who have had the intracapsular operation.*

There can be no question that any operation on an acoustic tumor is a difficult and somewhat hazardous procedure, but with patience and care they can now be removed completely in the vast majority of instances. If this is done, the patient will not only have as good a chance of coming through the operation as by the old intracapsular method, but will also have an infinitely greater chance of living a permanently useful life.

The one most serious drawback to the complete operation is the almost certain *facial paralysis, but this can be improved to some extent* by an anastomosis, and in our experience every patient with one exception has preferred this disability rather than to be faced with a recurrence of the tumor and a far more serious secondary operation. Olivecrona was able to spare the facial nerve in 15 out of 23 complete extirpations (Nielsen) but this is a much higher percentage than we have found possible. It may be that the sitting position which, of recent years, has been employed for this operation may make it easier to identify and save this important structure.

SUMMARY

A statistical study of the end results following intracapsular and complete removal of acoustic tumors has been made from our own material and from such other sources as are available. The five-year mortality rate for the intracapsular operation is well over 50 per cent whereas for the patients who have had complete tumor removals it is from 12 to 25 per cent. About one-third of the patients with intracapsular removals will be in useful life after five years and about two-thirds of those from whom the tumors have been totally extirpated.

The one *great disadvantage of the complete operation is a high incidence* of facial paralysis, but practically all patients in our own series have preferred to have this rather than a recurrence of their tumors.

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SPECIFIC TREATMENT OF INTRACRANIAL ANEURYSMS

Experiences with 143 Surgically Treated Patients

JAMES L. POPPEN

Considerable progress has been made in the past ten years in the surgical treatment of intracranial aneurysms. It has been possible to reach certain conclusions from the results obtained following the various surgical procedures that were instituted in 143 patients with verified intracranial aneurysms. These results, even though encouraging, indicate that much has to be learned about the management of intracranial aneurysms.

In the analysis of these 143 cases, one is impressed with the fact that intracranial aneurysms develop at favorite sites. Valuable information is thus gained from actual experience with aneurysms at specific locations and under specific conditions. Sufficient numbers of patients have been treated surgically to justify the recording of impressions gained from the procedures used.

Neurosurgeons who have had surgical experience with intracranial aneurysms realize the dangers and pitfalls that become obvious at the time of operation only after it is too late to avoid tragic results. It is not my purpose to discourage but rather to encourage surgical treatment, not only to save these patients' lives but to safeguard their usefulness while attempting to effect that cure. The actual excision or trapping of an intracranial aneurysm is technically not difficult. If in the execution of the excision or trapping, however, a patient is hopelessly and permanently crippled or his usefulness has been permanently damaged, one might wish that he had taken a completely conservative course rather than carry out a surgical procedure. At the present time there is no technic that will insure complete safety in carrying out surgical procedures which may be instituted in intracranial aneurysms. There are, however, indications and contraindications which are of the utmost importance for specific types of surgical procedures.

Two courses may be followed in the treatment of intracranial aneurysms, either conservative or surgical. Conservative treatment is justifiable only in a few instances, such as in bilateral multiple intracranial aneurysms (Fig. 394), arteriosclerotic saccular aneurysms with minimal symptoms, arteriosclerotic aneurysmal dilatations that have produced no serious local symptoms, and in cases in which inadequate collateral circulation prevents either direct or indirect surgical attack.

The surgical treatment of intracranial aneurysms cannot be instituted intelligently without knowing the exact site of the aneurysm. The surgeon must know the tolerance of each cerebral hemisphere to reduction in blood supply. He must know whether the aneurysms are solitary, multiple or bilateral. He should also

Originally published in Journal of Neurosurgery, 8:75–102 (Jan.) 1951.

know the risk involved in the non-surgical intervention versus surgical attack.

The proper treatment of intracranial aneurysms cannot be decided upon until adequate studies have been made. The diagnosis cannot be made with certainty until the presence of an intracranial aneurysm is verified by adequate arteriography. Even though spontaneous subarachnoid hemorrhage is a definite indication of the presence of a leaking or ruptured intracranial aneurysm, angiomas, blood-vessel malformations, mycotic emboli, blood dyscrasias, and fragility of blood vessels as found in hypertension or brain tumors may actually be the



Fig. 394. Angiogram demonstrating multiple unilateral aneurysms.

cause of the hemorrhage rather than the suspected aneurysm. Therefore, statistics as to the results of treatment of intracranial aneurysms must be based on actual demonstration of the lesion rather than on the mere presence of subarachnoid bleeding.

There should be no hesitancy in carrying out arteriograms at any stage of the subarachnoid bleeding. I am convinced, however, that arteriography should not be carried out under local anesthesia unless the superior cervical sympathetic ganglion and carotid sinus have been thoroughly anesthetized with procaine before the contrast medium is introduced. The peripheral cerebral arteries are at times in spasm from trauma to the arterial wall by the rupture of the aneurysm and the resulting perivascular extravasation of blood. The added insult caused by the injection of contrast media may induce further spasm, thus not only preventing adequate visualization but also possibly producing prolonged arteriospasm. The course of treatment that should be followed in each patient who is to be treated for an intracranial aneurysm can usually be decided from the arteriograms.

A few patients can be saved by surgical intervention at the initial attack o a subarachnoid hemorrhage if seen sufficiently early. It is, however, the patien who has had a recent (within one week) subarachnoid hemorrhage who shoul receive the most careful attention and study. There can be no question but tha further bleeding develops within the second and third weeks of the initial ruptur in a definite number of patients who survive the initial subarachnoid hemor rhage. It seems to be good judgment, therefore, to initiate surgical treatmen in these patients, granting that a certain number may not have a subsequen hemorrhage for many months or years.

CONSERVATIVE TREATMENT

As already indicated, conservative treatment is not justifiable except in specifi instances. After adequate studies have indicated that surgical treatment is a most certain to be followed by catastrophe, one naturally should forego surgery

INDIRECT SURGICAL ATTACK BY ARTERIAL LIGATION

The indirect surgical attack consists of ligation of a large artery or arteries i the neck, usually the internal carotid artery, in an attempt to lower the intra

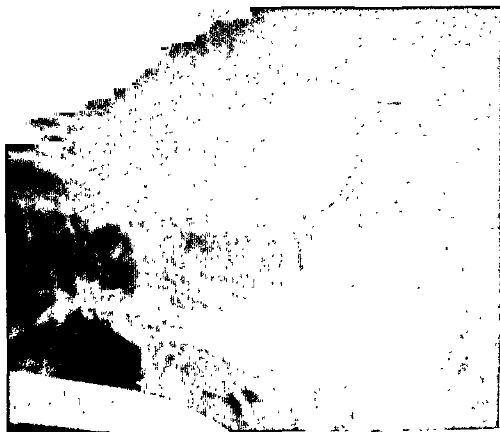


Fig. 395. Large globular aneurysm involving bifurcations of the larger arteries of the circle of Willis.

aneurysmal arterial pressure. The indirect attack is the procedure of choice in the majority of patients in whom the aneurysm is confined to the bifurcations of the larger arteries in the circle of Willis (Fig. 395). The indirect attack should not be utilized in aneurysms favorable for excision (Fig. 396) or in



Fig 396. Angiogram demonstrating saccular aneurysm favorable for excision.

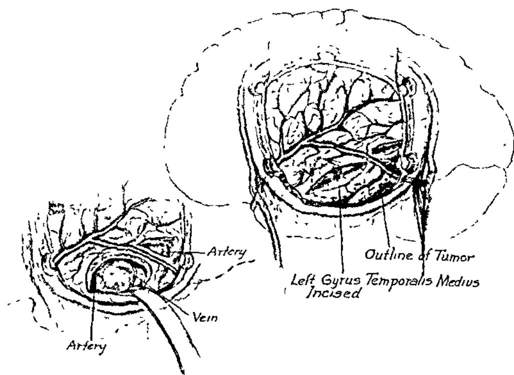


Fig. 397. Exposure of a large intracerebral aneurysm involving a temporal branch of the middle cerebral artery.

instances in which it could be of little or no value, as might be the case when the aneurysms are well away from the circle of Willis (Figs. 397, 398 and 399).

Several methods of ligation have been devised, no doubt because occlusion of the carotid system in the neck may be followed by serious sequelae. At times

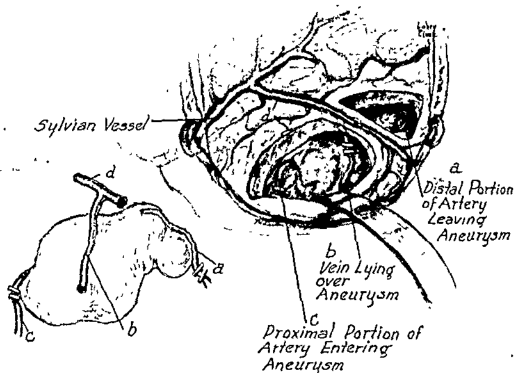


Fig 398. Uncapping of large aneurysm. *Inset,* Sketch of aneurysm after removal (see Fig. 399).



Fig. 399. Actual surgical specimen (See Fig. 398).

partial occlusion may be necessary in patients who do not tolerate complete interruption of the internal carotid artery. Partial occlusion of the carotid system may be obtained by the use of fascial strips, cellophane wrapping, special bands or partial interruption by silk ligatures. If partial interruption is necessary, I pre-

fer to make use of the normal structures, that is, ligate the common carotid artery which reduces the blood flow approximately one half or, if the ipsilateral cerebral hemisphere tolerates a greater reduction in blood flow, ligate the common carotid artery and the external carotid artery above the external maxillary artery. This allows several branches of the external carotid artery to feed the internal carotid artery.

Ligation of the internal carotid seems to be a safer procedure than ligation of the common carotid artery, providing the collateral cerebral circulation is adequate. The reason for this is perhaps the diameter and thickness of the arterial wall and also the fact that atheromatous plaques are found more frequently in the common carotid artery than in the internal or external carotid arteries. Great caution must, therefore, be exercised in avoiding acute constriction of the artery at the site of the calcified plaque, fracture of which will cause a rupture of the intima, resulting in the local formation of a thrombus. If the calcium deposit involves the entire wall of the common carotid artery, the ligature may weaken the wall to such an extent that a rupture may take place at the time of ligation, or a local false aneurysm develop later. I favor occlusion of the vessel chosen for ligation by taking advantage of the normal carotid sheath, imbricating it for a distance of 3 to 4 cm. with several layers of fine black silk until the lumen is completely closed, reinforcing this with a single larger black silk ligature on the cephalad and caudad ends of the vessel that has been completely occluded by the constricting layers of black silk. The silk sutures are tied down loosely so that they do not traumatize the intima but will prevent the lumen from reopening at a later date by stretching of the adventitial layer. Considerable care must be used in the exposure of the artery so that the sheath is kept intact. Also, trauma of the intima with a suture needle would obviate any advantage this method might offer. This technic has been described elsewhere.

I have hesitated to divide the internal carotid artery deliberately at the time of ligation as advocated by Rogers[1] and others. In one instance contralateral weakness of the extremities did not develop until two hours after ligation. Immediate return of function took place upon removal of the ligature. It is logical, however, to assume that dislodgment of an embolus is more likely to occur with occlusion in continuity than with interruption of the continuity because of the tug on the artery at the site of the ligature during each heart beat. It is possible that the percentage of serious consequences may prove to be less in patients in whom the continuity of the arterial wall has been interrupted. At the time of ligation, it is important that the carotid sinus is well anesthetized and the superior cervical ganglion perfused with procaine.

It has been my practice in the past either to divide the sympathetic trunk immediately beneath the superior cervical ganglion or to crush it in patients who had demonstrated irritability of the carotid sinus previous to ligation. This was also instituted in all patients with large subclinoidal aneurysms which had already caused ocular palsies from local pressure. More recently, however, to obviate a temporary or permanent Horner's syndrome, a polyethylene tube has been sutured into the sheath of the superior cervical ganglion and a slow concentrated procaine drip allowed to perfuse the ganglion for several days follow-

ing operation (Fig. 400). This accomplishes the desired effect as well as crushing or dividing the sympathetic trunk. Besides, it has the added advantage of preventing any prolonged undesirable effects of sympathetic interruption.

The precautions that should be used during and after ligation of the internal carotid artery are important. It is necessary to maintain a normal blood pres-

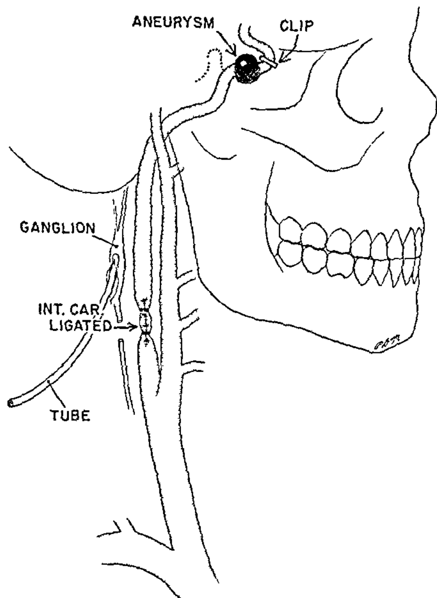


Fig 400. Trapping of an aneurysm of the internal carotid artery and method of interrupting sympathetic impulses with procaine by means of polyethylene tubing inserted into the sheath of the superior cervical ganglion for a period of several days following ligation. Division of sympathetic trunk is also shown, which may be done in certain instances.

sure and proper oxygenation, to use either local or regional anesthesia so that the patient's state of consciousness and reactions may be observed, to avoid trauma to the intima of the artery, to refrain from placement of a ligature over a sclerotic plaque, and to interrupt the carotid sinus and sympathetic trunk beneath the superior cervical ganglion. Interruption of the carotid sinus and sympathetic trunk was accomplished more recently by the use of polyethylene tubing and constant perfusion of the superior cervical ganglion with procaine for

two to three days following ligation. Adequate oxygenation should be continued for at least twenty-four hours following operation. Anticoagulation should be instituted four hours following ligation except in patients who have had a recent subarachnoid hemorrhage (within two weeks). Manipulation of the site of operation should be avoided during dressings for fear of dislodging a possible embolus.

There were 101 patients subjected to ligation of a large artery in the neck.

Three Deaths Following Ligation

Three deaths followed ligation. One patient, a 40 year old woman, with a history of hypertension, was seen fourteen hours following the initial hemorrhage. Bleeding continued and weakness of the left side developed. Angiograms demonstrated an aneurysm. Ligation of the right internal carotid artery was followed by death ten hours later. The second patient, a 65 year old woman, was seen eighteen hours after the rupture of an aneurysm which was visualized by arteriography; it involved the bifurcation of the left internal and middle cerebral arteries. Because of progressive signs, ligation of the internal carotid artery was performed. Four hours later a sudden left-sided or ipsilateral hemiplegia took place. Autopsy revealed a saccular aneurysm of the right middle cerebral artery which had ruptured. It was this patient who demonstrated so vividly that it is essential to visualize both carotid systems before a surgical procedure is instituted. The aneurysm on the side that was ligated was intact with the exception of a small thrombus at the site of the recent rupture. The third case demonstrates that anticoagulation is not without danger and should be avoided in patients who have recently had a subarachnoid hemorrhage. A 46 year old woman, with a vestigial aneurysm located at the bifurcation of the internal carotid and middle cerebral arteries on the right side, was subjected to ligation of the right internal carotid artery. Anticoagulation was instituted four hours after ligation. Unfortunately, the bleeding time was not adequately controlled and fresh, sudden bleeding occurred from the aneurysm, resulting in death.

These deaths emphasize the importance of adequate arteriography of both carotid systems before surgery is instituted, and that caution should be exercised in the use of anticoagulation agents. These agents should be reserved for patients, subjected to ligations, who have large aneurysms causing local symptoms but no history of rupture into the subarachnoid spaces, or for patients in whom the aneurysm has ruptured into the cavernous sinus.

Eight Subsequent Deaths Following Ligation

Case 1. A 66 year old woman, with hypertension, had sudden blindness and pulsating exophthalmos with complete ophthalmoplegia of the left eye twenty-four days previous to admission. She complained of severe left-sided headaches. Digital compression of either internal carotid artery in the neck caused untoward symptoms. Following anesthetization of the left superior cervical ganglion with procaine, digital compression was well tolerated. Arteriograms demonstrated rupture of an intracranial aneurysm into the left cavernous sinus. Partial ligation with cellophane and division of the sympathetic trunk on the left side were followed by a *right pulsating exophthalmos* and right hemiplegia twenty-two days later, and sudden death from pulmonary

mbolus twenty-four days after ligation. The circle of Willis as found at autopsy demontrated bilateral atresia of the posterior communicating arteries and bilateral saccular neurysms of the internal carotid arteries, with rupture into the cavernous sinus on the ːft and more recently on the right.

CASE 2. A man, 55 years old, had hypertension (200/120) and severe left-sided eadaches. Bilateral arteriography was done. Angiograms demonstrated a small saccular neurysm at the bifurcation of the left internal carotid and middle cerebral arteries. igation of the internal carotid artery with section of the sympathetic trunk was perɔrmed; no postoperative complications occurred. An excellent result was obtained for ne and one half years. The patient died suddenly from hypertensive cerebral hemorɦage on the right side, opposite the site of the aneurysm. Autopsy was not performed.

CASE 3. A woman, 36 years old, had pulsating exophthalmos, generalized convulions and periods of mental depression. Angiograms demonstrated a large aneurysm



Fig. 401. Angiogram demonstrating large aneurysm with venous communications.

vith venous communications (Fig. 401). The left internal carotid artery was ligated; ıo complications occurred. Subsequent roentgenograms demonstrated partial calcifiation in the wall of the aneurysm. She was well for nine years and then committed uicide.

CASE 4. A woman, aged 67 years, had sudden left-sided headaches and ophthalnoplegia of seven weeks' duration. Angiograms demonstrated an aneurysm at the ıifurcation of the internal carotid and middle cerebral arteries. Ligation of the common arotid and external carotid arteries distal to the external maxillary artery and section of he sympathetic trunk beneath the superior cervical ganglion were well tolerated. An xcellent result was obtained for three years. The patient died of cardiac disease.

CASE 5. A woman, aged 48 years, had right-sided severe headaches, severe trigeminal pain of the first and second divisions, poor vision in the right eye and nausea and vomiting of two days' duration. Examination revealed optic atrophy on the right and bloody cerebrospinal fluid. Right-sided angiograms only were made which demonstrated a large subclinoidal aneurysm. The common carotid and external carotid arteries were ligated above the external maxillary artery. Severe neuralgia persisted following ligation. Interruption of the continuity of the internal carotid artery and the sympathetic trunk was carried out, with complete relief two weeks later. She was well for four years and then blindness of the left eye developed due to a large aneurysm of the left internal carotid artery. She died five years following the initial ligation with blindness of the left eye and partial blindness of the right eye (ligated side).

CASE 6. A woman, aged 30 years, had periods of hallucinations for several years followed by sudden onset of right-sided headaches and subarachnoid hemorrhage. Angiograms demonstrated an aneurysm at the bifurcation of the left middle cerebral and internal carotid arteries. A right angiogram was not made. Ligation of the left internal carotid artery was well tolerated. Death occurred eighteen months later from subarachnoid hemorrhage, presumably from rupture of the aneurysm. Autopsy was not performed.

CASE 7. A man, aged 59 years, had right ophthalmoplegia of two months' duration and severe right-sided headaches. Angiograms demonstrated a vestigial aneurysm of the right internal carotid artery near its bifurcation. The common carotid artery, which was sclerotic, was ligated. There were no immediate complications. Four weeks later a large mass developed in the neck at the site of the ligation. Sudden rupture of a false aneurysm caused by ligation of the sclerotic carotid artery resulted in rapid death.

CASE 8. A woman, aged 26 years, had sudden severe headaches and subarachnoid hemorrhage. Angiograms demonstrated an aneurysm at the bifurcation of the left middle and internal carotid arteries. The left common carotid artery was ligated, with no resulting complications. She was well for one and one half years and then died suddenly, presumably from a ruptured aneurysm.

These subsequent deaths following dismissal from the hospital emphasize the importance of bilateral arteriography to rule out the presence of bilateral aneurysms. Also, ligations over an arteriosclerotic plaque should be discouraged. In only 1 instance was the ligation directly responsible for death. In 2 instances ligation was inadequate to prevent subsequent death, presumably from rupture of the aneurysm.

Hemiplegia Following Ligation

CASE 9. A woman, aged 32 years, had headaches, diplopia and convulsions. There was a history of several subarachnoid hemorrhages. Arteriograms demonstrated multiple unilateral aneurysms on the left side. Ligation of the left internal carotid artery was well tolerated for forty-eight hours, followed by a sudden complete right-sided hemiplegia and aphasia The speech returned within several hours but a permanent spastic gait resulted. Five years after ligation, the patient is able to carry out household activities with a brace on the right foot.

CASE 10. A woman, aged 39 years, had periodic generalized headaches. She had had three arachnoid hemorrhages. Arteriograms demonstrated a large saccular aneurysm at the bifurcation of the left middle and internal carotid arteries. Ligation of the in-

ternal carotid artery on the left side was followed by complete hemiplegia in eight hours. Speech returned in three weeks. Hemiplegia persisted to be incapacitating for three years. Gradual improvement has taken place in the past two years; she is able to do all her housework—cook, clean house, sew—and walks without support.

CASE 11. A woman, aged 56 years, gave a history of headaches and subarachnoid hemorrhage. Arteriograms demonstrated an aneurysm at the bifurcation of the middle and internal carotid arteries. Ligation was followed by complete hemiplegia in twelve hours. Incomplete recovery of the use of the extremities resulted. Five years later she was unable to carry out her normal household activities.

CASE 12. A woman, aged 27 years, had an arteriovenous aneurysm on the left, rupture having taken place into the petrosal and basilar sinuses. Ligation was carried out, with no untoward signs for eight days. Palpation of the operative site was followed by sudden hemiplegia. Complete recovery took place several days later.

CASE 13. A man, aged 49 years, gave a history of subarachnoid hemorrhage. Arteriograms demonstrated an aneurysm at the bifurcation of the left middle cerebral and internal carotid arteries. The left internal carotid artery was ligated and sudden hemiplegia occurred six days later. Speech returned promptly, but there was partial hemiplegia for one year.

CASE 14. A man, aged 27 years, had subarachnoid hemorrhage and persistent headaches. Arteriograms demonstrated aneurysms of the right anterior cerebral artery and occlusion of the left anterior cerebral artery. Ligation of the left internal carotid artery was followed by a sudden left-sided hemiplegia in thirty-six hours. Immediate recovery followed procaine block of the superior cervical ganglion.

CASE 15. A man, aged 49 years, had had a recent subarachnoid hemorrhage. An arteriogram demonstrated an aneurysm of the left internal carotid artery at its bifurcation with the middle cerebral artery. Sudden right-sided hemiplegia and aphasia developed six days after ligation. The aphasia began to improve after several hours, and slight movement started in the extremities following infiltration of procaine into the superior cervical ganglion. Partial hemiplegia prevents the carrying out of his usual activities up to the present date.

CASE 16. A woman, 67 years of age, had subarachnoid hemorrhage, right ophthalmoplegia and hypertension. Arteriograms demonstrated a large saccular aneurysm at the bifurcation of the internal carotid artery. Ligation of the right internal carotid artery was followed by left hemiplegia in two hours. Release of the ligatures resulted in dramatic, immediate return of the function of the left extremities. Seven days later the right internal carotid artery was ligated, with no ill effects. The patient is still alive seven years after ligation, with no complaints.

Relief of Symptoms Following Ligation

In 3 patients the pain in the distribution of the first and second divisions of the trigeminal nerve persisted following ligation. Two of these patients were completely relieved by division of the internal carotid artery, which had previously been ligated, and section of the sympathetic trunk immediately beneath the superior cervical ganglion The third patient was not relieved by this procedure and only after avulsion of the first and second divisions of the trigeminal nerve was the pain relieved. It is possible that in certain of these patients sensory

root avulsion may have to be instituted if the above minor procedures do not suffice to give relief.

Mental Symptoms Following Ligation of the Internal Carotid Artery

Three patients who were treated for intracranial aneurysms had definite hallucinations and periods of depression. These symptoms were present before ligation was carried out. In 1 patient it was necessary to perform a bilateral prefrontal lobotomy. At the time of the lobotomy a small aneurysm involving the

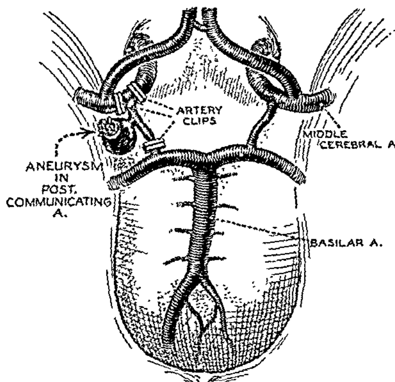


Fig 402. Trapping of ruptured aneurysm attached to posterior communicating artery which allowed adequate collateral circulation for the middle cerebral artery through the anterior cerebral arteries.

posterior communicating artery was trapped between silver clips (Fig. 402), with complete rehabilitation of the patient. No mental changes were noted as a direct result of the ligation of the internal carotid artery. Profound neurologic changes may take place following spontaneous occlusion of the internal carotid artery. This may well be due to changes that have taken place in the arterial walls of the intracranial arteries as well as in the internal carotid artery. Also, the activating agent producing the thrombosis may still be present, causing frequent or persistent arterial spasms. Improvement of symptoms in some of the patients who have spontaneous occlusion of the internal carotid artery may be obtained by excision of a segment of the internal carotid artery in the neck, combined with removal of the superior cervical sympathetic ganglion.

Roentgenologic Change in the Aneurysm Following Ligation

That healing after ligation does seem to occur in certain instances is indicated by calcification of the aneurysm, as demonstrated by Figures 403 and 404.

That aneurysms enlarge without treatment is indicated by Figure 405; arteriograms were taken at six-month intervals.



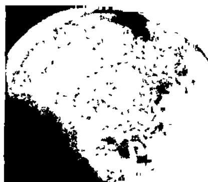


Fig. 403. Fig 404.

Fig. 403. Calcification in the internal carotid artery nine years following its ligation. (Reprinted by courtesy of Radiology, March 1949.)

Fig. 404. Calcification of an intracranial aneurysm five years following ligation.





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Fig. 405. Enlargement of a vestigial aneurysm in a six-month period.

DIRECT SURGICAL ATTACK

Direct intracranial surgical attack of intracranial aneurysms should be reserved for aneurysms that do not arise from the bifurcations of the larger arteries that make up the circle of Willis unless there is an adequate neck which allows occlusion at that point without interference with the main arterial trunks. This is rarely possible because of the attenuation of the walls of the artery at the neck of the aneurysm.

The direct intracranial attack may, in certain instances, be combined with the indirect attack, so-called trapping, in aneurysms that are proximal to the bifurcation of the internal carotid artery (Fig. 406) or in aneurysms that have ruptured into the cavernous sinus. Here again arteriograms must be made bilaterally; the arteriogram must satisfactorily demonstrate the technical possibility and *feasibility either of trapping or excising the aneurysm.* The arteriograms

must be studied from the standpoint of arterial plaques that at times involve the neck of the aneurysm.

Serious consideration must be given to the risk involved to the life of the patient; also, his usefulness following operation must be weighed against his chances without surgical interference.

Intracranial aneurysms in a favorable site for a direct attack should be trapped or excised. I firmly believe that excision should rarely be carried out except in instances in which the aneurysm is well away from the circle of Willis so that excision can be readily done. This is stated with a definite purpose in mind so that others may avoid the difficulties I have precipitated by actual excision of



Fig. 406. Arteriogram demonstrating parasellar aneurysm suitable for ligation of internal carotid artery in neck and intracranial occlusion distal to aneurysm.

aneurysms, wishing to study them grossly and microscopically, as well as to demonstrate that such excision was possible. That this is not feasible routinely may be appreciated by the fact that at times only 1 or 2 mm. of artery is available for the application of a ligature or a silver clip. The excision of the aneurysm next to the clip or ligature removes much of its support to the clip and may permit the clip to slip off the attenuated wall of the neck, or in the manipulation of the aneurysm in preparation for excision, the fragile wall of the neck may rupture before the clip is applied.

Specific Surgical Attack of Cranial and Intracranial Aneurysms

Aneurysms of the cranial portion of the carotid artery are extremely rare, no doubt because of the protection of the bony canal. If they do occur, the procedure of choice is ligation of the internal carotid artery in the neck and intracranial ligation of the internal carotid artery lateral to the optic nerve.

Aneurysms that involve the parasellar region should be trapped if sufficient length of the internal carotid artery distal to the aneurysm is available for the application of a silver clip or ligature. The question arises in these instances as to the sequence with which these procedures should be executed. I have ligated the internal carotid artery in the neck first in every instance except in 1 patient in whom the internal carotid artery was exposed and a ligature placed around it, the operative drapes having been prepared in such a manner that the craniotomy could be carried out at the same time. The intracranial portion of the internal carotid artery distal to the aneurysm was exposed and 2 silver clips



Fig. 407. Arteriogram demonstrating saccular aneurysm arising from the internal carotid artery suitable for excision or trapping intracranially.

applied. The internal carotid artery in the neck was simultaneously occluded by lifting the ligature which had previously been placed around it. The pulsation in the aneurysm ceased at the time the internal carotid artery was occluded by lifting the ligature in the neck. Upon release of the ligature in the cervical region, however, the pulsations became strong in the aneurysm and the silver clips previously applied to the intracranial portion of the internal carotid artery distal to the aneurysm could be seen to open slowly, and became displaced. The internal carotid artery was then ligated in the neck and the clips again applied. At this time there was no evidence that the clips would not permanently occlude the internal carotid artery intracranially. From a practical standpoint, therefore, it would seem preferable to ligate the internal carotid artery in the neck first, followed by occlusion of the distal intracranial portion of the internal carotid artery. If this is done immediately following the ligation it will prevent the

chances of thrombosis or embolus. If immediate ischemia takes place, however, nothing can be done about it. At the present time, therefore, I prefer first to ligate the internal carotid artery in the neck under local or regional anesthesia, to be followed by the intracranial ligation a few days later. Pedunculated aneurysms (see arrow) that arise from the internal carotid artery should be occluded (Figs. 407 and 408).

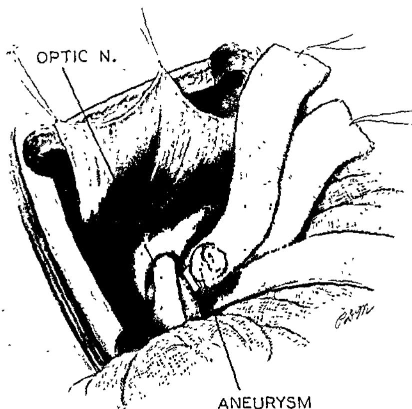


Fig. 408. Operative sketch of aneurysm shown in Figure 407.

ANEURYSMS AT THE BIFURCATION OF THE ANTERIOR PORTION OF THE CIRCLE OF WILLIS

Aneurysms at the bifurcation of the internal carotid artery, namely, the anterior and middle cerebral arteries, usually point posteromedially, however, they may point posterolaterally, anterolaterally or anteromedially (Fig. 409). The majority of aneurysms located at the junctions are outpouchings rather than pedunculated. If pedunculated, the neck of the aneurysm is rarely long enough to allow its occlusion with a clip or ligature. I have attempted excision in 2 such instances. In an attempt to mobilize the aneurysm gently from the moderately dense arachnoidal adhesions that in many instances surround it, rupture took place, resulting in ligation of the major vessels in an effort to save the patient's life. One of the patients succumbed within twelve hours without regaining consciousness. The second patient regained consciousness and seemed to be in good condition with the exception of contralateral paralysis of the extremities,

but died suddenly thirty-six hours following completion of the operation. Autopsy revealed a fresh intrapontine hemorrhage. The operative site showed no evidence of bleeding.

These experiences have greatly curtailed my enthusiasm for a deliberate attack on aneurysms arising from the bifurcations (Fig. 410), and at the present time ligation of the internal carotid artery is the procedure of choice. It is possible that occlusion of the internal carotid artery in the parasellar region may avoid the complications that have attended the ligations in the neck.

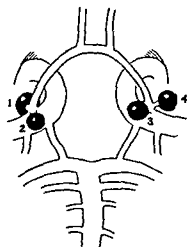


Fig. 409.



Fig. 410.

Fig. 409. *1*, Anteromedial location at bifurcation, 2, aneurysm placed posteriorly, *3*, aneurysm located posteromedially, with large neck, *4*, aneurysm located anterolaterally with small neck. Fig 410. Aneurysm arising from bifurcation of internal and middle cerebral arteries unsuitable for direct attack.

VESTIGIAL ANEURYSMS

Vestigial aneurysms usually arise from the posterior portion of the internal carotid artery in the proximity of the posterior communicating or anterior carotid artery, but may arise from any portion of the internal carotid artery intracranially. These aneurysms develop in vestigial embryonic remnants and are commonly mistaken for aneurysms involving the posterior communicating artery.

The vestigial aneurysms form a favorable group for trapping or excision, as indicated by Figures 411 and 412, *a* and *b*. It is important to study the arteriograms carefully, with particular attention directed to the neck of the aneurysm. The majority of these aneurysms are pedunculated. In several instances, however, arteriosclerotic plaques occurred in the neck; the latter are not visualized by the usual roentgenographic studies. Arteriograms may demonstrate a small defect, indicating such a condition (Fig. 412, *b*). Placing a silver clip over an attenuated wall changed by an atheromatous plaque may well result in rup-

ture of the vessel at the time of ligation and end in catastrophe. Ligation of the internal carotid artery is preferable in cases in which the neck of the aneurysm is involved with such a condition.



Fig. 411. Vestigial aneurysm suitable for excision.

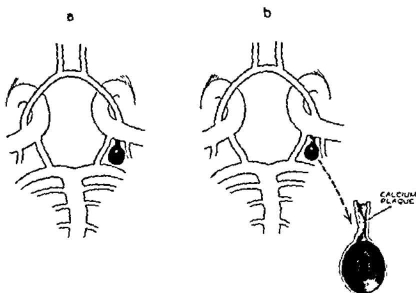


Fig. 412. *a*, Sketch illustrating usual site of vestigial remnant aneurysm. *b*, Appearance in neck of a vestigial aneurysm involved with a calcium plaque.

ANEURYSMS OF THE ANTERIOR CEREBRAL ARTERY

The surgical treatment of fusiform and pedunculated aneurysms arising from the trunk of the anterior cerebral arteries presents no particular problem (Fig. 413, *a* and *b*). Excision or trapping of the left anterior cerebral artery must be executed under ideal situations, great care being exercised to keep the blood

pressure at a normal level and to maintain proper oxygenation during an(the operation.

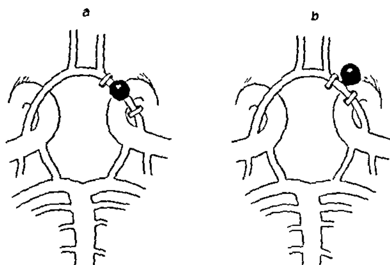


Fig. 413. *a* and *b*, Trapping of aneurysms of the main trunk of the anterior cerebra regardless of whether they are fusiform or pedunculated.

ANEURYSMS ARISING FROM THE ANTERIOR COMMUNICATING ARTERY

Aneurysms of the anterior communicating artery present a particular pr(Unfortunately, the anterior communicating artery is an arterial communi(

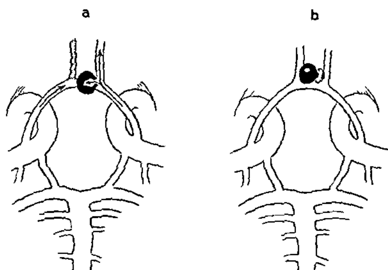


Fig. 414. *a*, Aneurysm at bifurcation of anterior cerebral and anterior commun arteries, its neck arising from the right anterior cerebral artery, and spontaneous thro of left anterior cerebral artery Arteriograms demonstrated filling only from right s Pedunculated aneurysm suitable for occlusion with silver clip, allowing normal circula both anterior cerebral arteries.

of only a few mm. in length, between the two anterior cerebral arterie aneurysm of any size involves the entire length of the artery. Here agai aneurysm usually arises from the junction of either anterior cerebral artery the anterior communicating artery (Fig. 414, *a* and *b*). Arteriography is most importance to determine from which anterior cerebral artery the ane

seems to arise, or from which anterior cerebral artery it derives most of its blood supply. If the angiograms demonstrate that the contrast medium fills the aneurysm only from one side (Figs. 415, *b*, and 416), occlusion of the anterior cerebral artery proximal and distal to the aneurysm is the procedure of choice. If the aneurysm is pedunculated and is sufficiently large, a silver clip should be placed on its neck (Fig. 414, *b*). In none of the patients in this series was this possible.

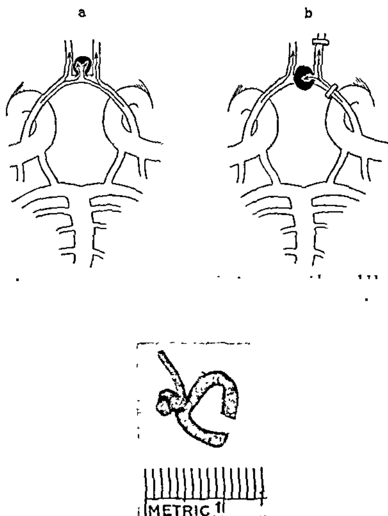


Fig. 416. Actual surgical specimen demonstrating aneurysm at bifurcation of anterior cerebral and anterior communicating arteries.

If the aneurysm fills equally well from each anterior cerebral artery (Fig. 415, *a*) the aneurysm should not be subjected to direct surgical attack. It is almost impossible to mobilize such an aneurysm safely without rupture or, if this could be done, it would be necessary to sacrifice both anterior cerebral arteries and thus produce a bilaterally lobotomized patient. This procedure is attended with more profound mental changes owing to the occlusion of the callosal vessels in addition to sacrifice of both anterior cerebral arteries. In 2 patients thrombosis of the contralateral anterior cerebral artery (Fig. 414, *a*) was noted. The right arteriogram demonstrated that the aneurysm filled adequately; the left arteriograms, on repeated attempts, did not visualize the anterior

cerebral artery. Occlusion of that anterior cerebral artery was verified by operation. The ipsilateral anterior cerebral artery distal to the aneurysm may also become occluded spontaneously, either as a result of vasospasm from trauma caused by the aneurysm itself or by disease in the wall of the artery as well as in the aneurysm. In the latter instance, occlusion of the anterior cerebral artery shortly after it leaves the internal carotid artery is indicated.

ANEURYSMS ARISING FROM THE MIDDLE CEREBRAL ARTERY

Nonpedunculated aneurysms of the main trunk of the middle cerebral artery cannot be trapped or ligated without disastrous results (Fig. 417). Fortunately,

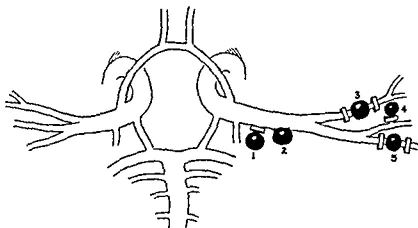


Fig. 417. Various types of aneurysms at different locations on the middle cerebral artery. *1*, pedunculated type suitable for occlusion; *2*, aneurysm with outpouching unsuitable for local excision; *3*, branch of middle cerebral artery which may be sacrificed; *4*, pedunculated type which may be excised; however, a fusiform aneurysm would cause considerable disability, *5*, temporal branch which may be sacrificed.

a few aneurysms arise from the middle cerebral artery after it has divided. Arteriography, again, is essential to determine whether the aneurysm arises from a branch that may be sacrificed without causing permanent invalidism.

ANEURYSMS ARISING FROM THE POSTERIOR COMMUNICATING ARTERY

The posterior communicating artery is infrequently involved; this occurred in only 2 of the 143 patients. If a small aneurysm does arise from the posterior communicating artery, it can either be excised or trapped, as in Figure 402. If, however, the aneurysm involves the entire posterior communicating artery, surgical trapping or excision can only meet with disaster. I have no suggestions for treatment of this particular type of aneurysm unless consistent filling is demonstrated by either carotid or vertebral arteriograms. If it can be demonstrated that only one of these fills the aneurysm, ligation of that particular vessel might be considered. Fortunately, aneurysms of the posterior communicating artery occur rarely. Many aneurysms reported and thought to arise from the posterior communicating artery represent aneurysms in vestigial embryonic arterial remnants.

DISSECTING INTRACRANIAL ANEURYSMS

Two dissecting aneurysms (Figs 418 and 419) were found in this group. I have been unable to find previous reference to this particular type of intracranial

aneurysm in the literature. The type of treatment depends entirely upon the location. As shown in Figure 418, the aneurysm was located in a region that was readily accessible for complete excision. In Figure 419, however, since the aneurysm involved the medial trunk of the middle cerebral artery, excision would have been followed by severe incapacitation. Ligation of the internal carotid

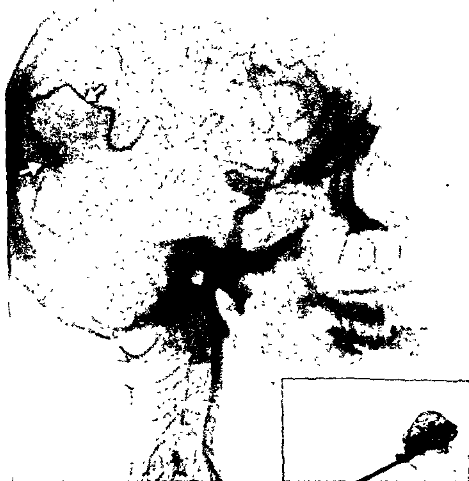


Fig. 418. Dissecting aneurysm involving the angular branch of the middle cerebral artery. *Inset*, Specimen following removal.

artery was performed, with complete relief of symptoms up to the present time (eight years).

ANEURYSMS THAT HAVE RUPTURED INTO THE CAVERNOUS SINUS

Many lives are saved by the rupture of an aneurysm into the cavernous sinus rather than into the subarachnoid space. The clinical manifestations are intriguing. A bruit is present, either objectively or subjectively, in all instances. A pulsating exophthalmos is not necessarily present in all instances. In 1 patient the pulsating exophthalmos was present on the side opposite the communication between the aneurysm and the cavernous sinus. The reason for this is that much depends on the actual site of the fistula in the cavernous system (Fig. 420), and also on the relationship of the bulk of the aneurysm to the sinus and fistula. If

the intracavernous aneurysm is centrally placed with only slight compression of the venous channels, the arterial blood may flow in either direction (Figs. 421 and 422). A large subclinoidal aneurysm occluding the cavernous sinus unilaterally with the fistula pointed posteriorly will fill the posterior intercavernous, basilar and petrosal sinuses (Fig. 423). A fistula in the medial anterior portion will cause the arterial blood to rush into the anterior intercavernous sinus, causing an exophthalmos on the opposite side.



Fig. 419. Dissecting aneurysm of the middle cerebral artery.

The treatment consists of ligation of the internal carotid artery in the neck, and intracranially distal to the fistula In certain patients with persistent exophthalmos following ligation it may be necessary to excise large aneurysmal intraorbital veins after unroofing the orbit. This can readily be done at the time of the intracranial carotid ligation. This procedure was necessary in 3 patients in whom the exophthalmos did not subside following extracranial and intracranial ligation, because of thrombosis of the superior and inferior ophthalmic veins.

ANEURYSMS OF THE VERTEBRAL ARTERY

Trapping or excision is the procedure of choice if the opposite vertebral artery supplies adequate collateral circulation. The smaller aneurysms can be attacked in this manner; however, large saccular aneurysms may be completely inoperable with the exception of ligation of the vertebral artery on the ipsilateral side.

Fusiform aneurysmal dilations in most instances are not amenable to surgery or any other form of treatment.

ANEURYSMS OF THE BASILAR ARTERY

Fusiform aneurysmal dilatations of the basilar artery are common. Surgical intervention is of no help nor can large saccular aneurysms be attacked surgically with any degree of safety.

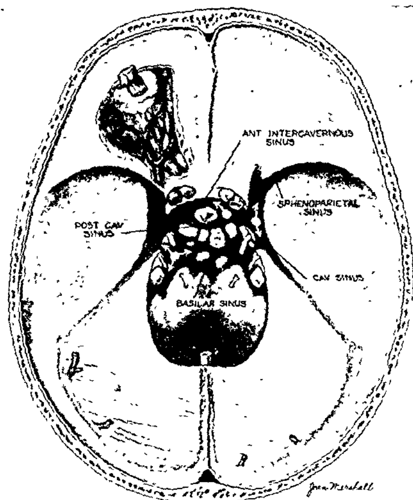


Fig. 420. The ... in the cavernous system, deper... by the circular dots. The flo... the extent to which it has occluded the ...

It is conceivable that if the anastomosis of the internal carotid artery to the jugular vein in the neck bilaterally proves to be practical in the adult or if vertebral arteriovenous anastomosis is practical, aneurysms of the branches of the basilar artery could be excised or trapped if their size does not make the procedure prohibitive.

ANEURYSMS WITH RUPTURE INTO SOFT TISSUE OR VENTRICLE

Rupture of an intracranial aneurysm occurs most frequently into the subarachnoid spaces. In 12 patients, however, the hemorrhage extended into the



Fig. 421. Large *subclinoidal aneurysm with arterial blood flowing in all directions: 1*, a large superior ophthalmic vein; 2, the beginning of the inferior ophthalmic vein; 3, the aneurysm and cavernous sinus filled with dye.



Fig. 422. Aneurysm ruptured into the cavernous sinus with arterial blood entering mainly the sphenoparietal sinus and sylvian veins.

soft tissues of the brain, most frequently into the temporal lobe (Fig. 424). The intracerebral hemorrhage in 2 patients ruptured into the lateral ventricle.



Fig. 423. Aneurysm with rupture into the basilar sinus.



Fig. 424. Vestigial aneurysm with displacement of the middle cerebral arteries upward and anteriorly, owing to extravasation of blood into the soft tissues of the temporal lobe. (Retouched.)

This complication is perhaps due to thickening of the arachnoid around the aneurysm because of local irritation, the adhesions preventing the hemorrhage

from entering the subarachnoid spaces. The site of the aneurysm influences to a great extent the occurrence of intracerebral bleeding. Aneurysms of the branches of the middle cerebral artery frequently are the sources of intracerebral hemorrhage.

ANEURYSMS ASSOCIATED WITH ESSENTIAL HYPERTENSION

Any patient who has an intracranial aneurysm associated with marked hypertension should be subjected to thoracolumbar sympathectomy and ligation of the internal carotid artery if other medical measures are insufficient to keep the blood pressure within reasonable limits.

Result of Direct Intracranial Attack

Intracranial Trapping. Eighteen patients were subjected to intracranial trapping, with 1 operative death. In that patient a silver clip was placed over the neck of the aneurysm in which there was an atheromatous plaque, resulting in rupture of the wall of the artery. The patient died eight hours after operation without regaining consciousness.

Excision of Aneurysm. Fourteen aneurysms were excised intracranially, with 2 operative deaths. The aneurysms were located at the bifurcation of the internal carotid artery and middle cerebral artery. One of the patients, however, was in extremis at the time the surgical procedure was instituted, because of bleeding.

Exposure of Aneurysm Intracranially with Attempted Mobilization and Excision. Four large aneurysms in the circle of Willis were exposed in an attempt to mobilize them for excision or trapping. The execution of this was prevented by the size of the aneurysm. Three patients died as a result of exposure and mobilization of the aneurysm. The fourth patient died six months later.

Large Intracranial Aneurysms Arising from the Circle of Willis. Four large intracranial aneurysms arising from the circle of Willis in the parasellar region, supraclinoidal in position, were exposed. A great portion of the organized clot was removed from the aneurysmal sac, muscle was inserted into the evacuated area and the wall of the aneurysm imbricated with black silk. This resulted in 1 operative death, the patient dying one day following dismissal from the hospital from a sudden fatal hemorrhage. Two subsequent deaths occurred, 1 patient dying in one and one-half years and the other three years following this procedure. One patient has survived for over twelve years.

COMMENT

It may be noted that intracranial trapping, whenever feasible, is attended with a low mortality as well as a cure; the one exception was the patient who died one year after operation from a subarachnoid hemorrhage from an unsuspected aneurysm on the opposite side. It is not justifiable, therefore, to institute surgery of any type in these patients without demonstrating to the best of one's ability the absence of multiple or bilateral aneurysms. The excision of aneurysms also is attended with a reasonably low mortality if aneurysms that arise from the bifurcations are not included For that reason I strongly recommend great caution before decision is made to attack an aneurysm that arises from a bifurca-

tion unless a suitable neck for the application of a silver clip can be demonstrated.

It is my impression that evacuation of a portion of organized clot from a large intracranial aneurysm has no particular merit either in relieving symptoms or in prolonging life. Most of these patients would have done as well with ligation as indicated by the results obtained from ligation of the internal carotid artery in subsequent patients in whom similar aneurysms were found. It is worthy of note, however, that the patients who died following exposure of the aneurysm and imbrication of the wall over muscle tissue did not have ligations of the internal carotid artery. Of the patients who survived, the internal carotid artery had been occluded by ligature. It is possible that in a few instances in which the local symptoms are grave, ligation followed by evacuation and support by muscle might be worth while.

Exposure of a large intracranial aneurysm directly attached to the circle of Willis should be discouraged in all cases.

Death occurred in patients who were not carefully chosen; in patients in whom the aneurysm was exposed before arteriography became a routine diagnostic procedure and in patients in whom the site of the aneurysm precluded surgery.

Only one reference has been included although several valuable publications have appeared in the literature. Since the opinions voiced in this publication are based entirely on a personal surgical experience with 143 patients, references have been purposely omitted. Since completion of this paper a total of 164 verified intracranial aneurysms have been treated surgically.

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CERVICAL RIB

JAMES L. POPPEN, J. F. KENDRICK AND W. E. SMITH

ANATOMY AND PATHOLOGY

The subject of cervical rib and related syndromes has been presented in numerous reports. We wish to add a series of cases and possibly clarify somewhat various anatomical, pathologic and surgical relationships as they occur in the "musculo-osseous pyramid" of the neck and shoulder. This term is used to signify the three-sided pyramid which anatomically is formed in the following manner. The base may be considered the cervicothoracic spine and the great vessels, including the carotid artery and internal jugular vein—bounded by the sternocleidomastoid muscle anteriorly, the scalenus medius and posticus muscles posteriorly and the cervical or first dorsal rib inferiorly. The dorsal wall of the pyramid is a sheet of muscles including the middle and posterior scalenus, the levator scapulae, trapezius and the subscapular. The ventral wall is formed by the sternocleidomastoid muscle, the pectoralis major and minor muscles, the coracoclavicular fascia, the clavicle and the subclavius muscle. Inferiorly, the third side of the pyramid is formed by the first and second dorsal ribs, serratus anterior muscle and the cervical rib, if present. Directly under these lies Sibson's fascia covering the apex of the lung. Finally, the apex of the pyramid points laterally and opens into the axillary fossa at the lateral border of the pectoralis minor where the brachial plexus branches into its terminal five divisions.

Within this pyramid the structures of clinical and surgical importance are the brachial plexus, the subclavian artery and its divisions, particularly the transverse cervical and transverse scapular arteries, the anterior and middle scalene muscles, the subclavian vein, the cervical or first dorsal rib or both, the phrenic nerve, the carotid sheath and included structures (nerve, artery and vein), the left thoracic duct, and to a lesser extent, the right thoracic duct. Any increase in the contents or encroachment on them without an increase in the volume of the encasing pyramid usually causes symptoms. The same may be said of conditions producing torsion or strain on the shape or the volume of the contents. Through the middle of the base region of this pyramid runs the scalenus anticus muscle. Posterior to this muscle lie the roots of the brachial plexus and *in almost all instances the subclavian artery, although it may pierce* the muscle or may be entirely anterior to the muscle. The subclavian vein apparently lies anterior to the anterior scalenus muscle in almost all patients. The phrenic nerve emerges between the scalenus medius and anticus and proceeds on the anterior surface of the scalenus anticus medially and inferiorly into the mediastinum. Medial to the scalenus anticus lie the carotid sheath and its contents. Consider-

Originally published in Surgical Clinics of North America, 30 843–851 (June) 1950.

ing this central location of the scalenus anticus muscle and its vertebral and rib attachments, it is easily seen why this structure may cause so much difficulty.

Embryologically, all ribs begin with costal processes which originate from the primitive vertebral mass. In the human being, only the thoracic region contains fully developed ribs. In the cervical region the costal process fuses the head with the body of the vertebra and the tubercle with the transverse process. In this manner a transverse foramen is formed by each cervical vertebra bilaterally. At times there may be a congenital overdevelopment of the costal process or the transverse process, which may vary in length up to a complete rib which articulates with the manubrium. In many instances, the cervical rib is jointed, forming a costochondral junction with the first rib.

Developmentally, a cervical rib may vary from a small bony projection to a fully developed rib as seen in the case of thoracic ribs. There are numerous reports of double or bifid cervical ribs in the literature. Also, the various anomalies of cervical ribs have been reproduced by the first dorsal ribs.

Cervical ribs are usually bilateral but may be unilateral. When bilateral, one rib is more fully developed than the other. At times cervical ribs may be associated with congenital defects, such as club foot, club hands, imperfect development of the clavicle, shoulder or vertebrae, torticollis, syringomyelia, multiple sclerosis and progressive muscular atrophy. Cervical ribs seldom cause symptoms prior to puberty owing to the delay in ossification and completion of growth of the ribs and delay in shoulder descent. With the course of skeletal development there is a gradual descent of the shoulder. The greater part of this depression, however, does not occur until after puberty, and in many patients does not take place until later in life with onset of muscle laxity and loss of tone. In females the descent is greater and the final position of the shoulder more sloping. Lifting or carrying heavy objects may depress one or both shoulders, producing symptoms. The thoracic cage is relatively higher in patients with cervical ribs, increasing both the opportunity for tension on the nerve and vascular structures and the tendency to compression between the scalene muscles as well as between the clavicle and the ribs.

Another cause which may frequently be related to the onset of clinical symptoms is trauma to the supraclavicular region directly or by pull or strain exerted through the upper extremity. Trauma may be insidious, as in the thoracic type of respiration seen in females. The stage must, of course, be set by embryologic and developmental processes long before the onset of trauma in most patients.

SYMPTOMS

The age of onset of symptoms varies markedly from the time of puberty to old age. Cervical ribs, as well as their symptoms, occur predominantly in females. The ratio of females to males varies; however, in our group, it was 7 to 1. It is estimated that cervical ribs occur in 0.03 to 0.1 per cent of the total population. Only 5 to 10 per cent of persons with cervical ribs have symptoms referable to the ribs. Cervical ribs occur more frequently on the left than the right. However, symptoms are usually greater on the right side, probably because most individuals are right handed. Thus, there is an occupational predisposition of

this syndrome in patients with repeated minor insults such as lifting or carrying objects repeatedly, working with the arms up over the head, or using one or both shoulders in a position of depression. In other words, the arms are used in a position causing traction or tension, thus placing stress or volume change on the pyramid and neurovascular structures.

The symptoms vary markedly and may be local, nervous, vascular or muscular. Usually, however, it is the neurocirculatory system which is predominantly involved and produces symptoms. Local symptoms include visible or palpable deformities in the neck or supraclavicular fossa. Chronic injury to the subclavian artery produces aneurysms at times at the site of the compression. Many times a thrill or bruit may be found. This may be due only to the compression of the subclavian artery by the anterior scalenus muscle and associated structures or due to an aneurysm.

The nervous symptoms are primarily those of various forms of pain—sharp, dull, aching, stationary or radiating, and multiple other types including paresthesias. These symptoms may occur from the occipital region and neck to the fingers, and include the anterior chest, shoulder, upper back and axilla. Facial pain at the angle may be present owing to sympathetic involvement or actual compression on the cervical trunks that innervate the angle of the jaw. The most common pattern of pain is in the shoulder, medial brachium, antebrachium and ulnar portion of the hand. The medial and radial components may also be involved. Associated with the pain the subjective symptoms are those of either hypesthesia or hyperesthesia or they may manifest themselves by paresthesias. Infrequently a Horner's syndrome may be associated with a cervical rib, particular when there is sympathetic involvement.

At times there is a mild weakness in one or more muscles of the arm which may progress to paralysis with atrophy of varying degrees. These are usually noted in the forearm and intrinsic muscles of the hands. Peripheral vascular changes are frequent symptoms manifested by coolness of the involved extremity, dusky, purplish hue or blanched appearance, increased perspiration, or trophic changes ranging from fine skin excoriations to ulcer formation and gangrene. Trophic changes of the nail also may take place. In others there may be marked venous distention and edema of the extremities. Thrombosis with absent subclavian, axillary, brachial, radial or ulnar pulsations may take place.

Of infrequent occurrence are venous obstruction involving the subclavian vein due to costoclavicular compression, phrenic paralysis due to cervical rib or anterior scalene pressure and recurrent laryngeal involvement with hoarseness.

DIAGNOSIS

In an attempt to establish the diagnosis, the routine physical and neurologic examinations as well as the well-known tests of Halsted,[4] Naffziger[8] and Adson[1-3] should be carried out. Ochsner[9] also described a test for vascular occlusion by the scalenus anticus. McGowan[6-7] described a test for costoclavicular compression that is often of use and is called the "position of attention" in which the shoulders are thrown backward and down. At times infiltration of the scalenus anticus muscle with procaine may be used for diagnostic and therapeutic

reasons. Of prime importance are adequate roentgenograms of the cervicothoracic spine, including the oblique film since in many instances posterior eagle-beaking, occurring at one of the intervertebral foramina due to osteo-arthritis, may be the cause of the symptoms rather than cervical rib. We have been particularly suspicious of the diagnosis of anterior scalenus muscle syndrome without the presence of osseous changes such as a cervical rib or an elongated transverse process. The differential diagnosis should include protrusion of a cervical intervertebral disk, neoplasms in the spinal canal, syringomyelia, neoplasms of peripheral nerves, neoplasms of the superior pulmonary sulcus, aneurysms of the subclavian artery having a different etiology from trauma by a cervical rib or a fascial band, subacromial bursitis, rupture of the supraspinatus tendon, myositis, fibrositis, cervical arthritis, Raynaud's disease, thrombo-angiitis obliterans, transitory torticollis, inflammatory toxic neuritis of the brachial plexus and post-operative scarring following operation in the supraclavicular fossa.

ANALYSIS OF 58 CASES

This paper is concerned with 58 cases of cervical ribs from 115 cases of scalenus anticus syndrome seen in the past ten years. These patients were operated on after conservative measures had failed. The clinical findings were as follows: there were 51 females and 7 males, a ratio of 7 to 1. The ages ranged from 4 years to 54 years; the cervical ribs were found more commonly in patients in the second, third and fourth decades. Forty-six patients had bilateral cervical ribs, 8 unilateral on the right and 4 on the left. Four patients had associated abnormal first thoracic ribs. Cervicodorsal scoliosis was noted in many of these patients. Three patients had spina bifida occulta either in the cervical or lumbar region and 3 patients had associated syringomyelia. The Klippel-Feil syndrome was noted in 2 of the patients.

The duration of symptomatology varies from three weeks to thirty-five years, most commonly one month to two years.

Symptoms were bilateral in 7 patients, on the right in 25 patients and on the left in 26. The symptoms in patients with unilateral ribs always occurred on the side of the rib. In 6 patients with bilateral cervical ribs, however, the side of the shorter rib rather than the longer rib caused symptoms.

There was a history of trauma in 11 patients varying from direct blows in some form of athletics to the placing of a patient in an abnormal position during induction of anesthesia. Weight loss because of continuous pain was noted in 5 patients. Swelling in the neck on the side of the rib was discovered by 8 patients. However, examination revealed a mass in the supraclavicular fossa in 54 of the patients. In 42 patients tenderness and numbness were noted in the angle of the jaw. In 5 patients pain was referred to the ear and temple regions, in 11 patients to the back of the neck unilaterally, to the shoulder in 35 patients, to the thoracic region in 18 patients, to the arm in 43 patients, to the forearm in 44 patients and to the hand in 29 patients, in 26 of the latter being in the ulnar distribution, and in 11 predominantly in the radial segments. Motor weakness was demonstrated in 28 patients either in the ulnar or radial segments, predominantly the ulnar. Atrophy of the intrinsic muscles of the hand and vaso-

this syndrome in patients with repeated minor insults such as lifting or carrying objects repeatedly, working with the arms up over the head, or using one or both shoulders in a position of depression. In other words, the arms are used in a position causing traction or tension, thus placing stress or volume change on the pyramid and neurovascular structures.

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idea of doing a complete sympathetic denervation of the left upper extremity at a later date, should this be necessary.

Postoperatively, the patient had no return of function or of feeling in the left arm or hand, but the hand was definitely warmer. The wound healed per primam and the patient was discharged on October 29, 1942, slightly improved. She was to receive daily physiotherapy and be closely followed.

On December 13, 1943, there was no anesthesia although hypesthesia extended to the mid-antebrachium. Circulation remained fairly good but no radial or ulnar pulsation was felt. Extension at the elbow was done well but there was little flexion. Slight flexion was noted at the wrist and also in the fingers. Abduction was limited to 90 degrees at the shoulder but the other shoulder movements were well performed. She could support her whole body with the left arm. On June 15, 1944, she had improved still more and was continuing daily physiotherapy.

On November 10, 1944, it was decided that the patient's hand was becoming colder and that she should be admitted for dorsal sympathectomy on the left. Accordingly, she returned to the New England Deaconess Hospital on February 13, 1945. On February 15, 1945, segmental avulsion of the roots of the second and third thoracic ganglions on the left (nerves and communicating sympathetic rami) was done, and the sympathetic chain was sectioned below the third thoracic ganglion and the proximal portion sutured into muscle.

Postoperatively, the patient's left upper extremity was quite warm. The incision healed well and the patient was discharged on February 24, 1945. She has not returned for further follow-up study but a letter from her local physician states that her arm is still quite weak and presents some atrophy but the vascular components seem to be adequate.

Case 2. This 25 year old white man was struck across the upper chest and neck when a hoist gave way on a coal truck, with a resultant crushing type injury, three weeks before admission to the New England Deaconess Hospital on March 24, 1948. At that time he suffered a fracture of the seventh cervical vertebra and of a bone in the right upper chest, with immediate paralysis of the right arm. He was not unconscious but was cyanotic for a short period of time. He had had rather extreme soreness and pain on motion of the right upper extremity which had improved slightly along with some return of voluntary use of the upper arm and shoulder. At first he was unable to move the right arm or hand. At the time of admission he could voluntarily flex, extend, supinate and pronate the arm and flex and adduct the fingers, all to a slight extent.

Examination revealed fairly good function of the right deltoid, biceps, brachioradialis and supinator. The triceps was rather weak. There was paralysis of all the intrinsic hand muscles and he was unable to extend the wrist. There was slight action of the flexors of the fingers and the wrist. A marked tenderness of the right neck and supraclavicular fossa was noted. The right hand was slightly swollen, red, warmer and drier than the left. A Horner's syndrome was not present. Sensory examination revealed paresthetic sensation over the lateral brachium and over the volar and dorsal aspects of the antebrachium and hand—more marked radially than to the ulnar side. Roentgenograms showed small cervical ribs bilaterally with anterior dislocation of the right cervical rib and fracture of the transverse process with anterior displacement of the distal fragment which measured approximately 4 by 5 mm. The remainder of the spine appeared normal.

On March 27, 1948, operation revealed that the cervical rib on the right was fractured irregularly and transversely about 0.5 cm. lateral to the attachment to the trans-

the sympathetic ganglionated chain from the second and third intercostal nerves and sectioning the chain below the third thoracic ganglion was carried out on January 20, 1941. Following this, the patient made a rapid and uneventful recovery. The temperature and color of the left hand approximated normal, and he was discharged on February 1, 1941, much improved. No radial pulse was noted at this time.

The patient was seen two months later at which time he still complained of some left shoulder pain. His hand was progressing well in strength, color and warmth, and the radial pulse was becoming apparent. In February 1945 his only complaint was a rippling sensation in the left neck. This was thought to be due to a dilated left suprascapular artery. His hands were similar and normal in appearance. The radial artery, though still fairly feeble, was palpable. The result in this case was thought subjectively by the patient and objectively by examination to be very good.

TREATMENT

Treatment for cervical ribs may be divided into operative and nonoperative methods, According to Paull,[10] nonsurgical therapy should have as its aims, (*a*) avoiding positions responsible for the syndrome when practicable, (*b*) widening the costoclavicular space, (*c*) lengthening the involved neurovascular structures, (*d*) reducing the acuity of the angle these structures traverse as they pass under the coracoid process while the arms are hyperabducted, and (*e*) shortening the course traversed by these structures. These aims are best brought into action by exercises designed to elevate the shoulders and bring them forward and by stretching the arms by such exercises as require hanging by the hands supporting the weight of the body. Other conservative therapy includes application of heat to the supraclavicular area by mechanical means, infra-red rays or diathermy. The shoulders may be lifted and splinted if need be by means of a sling. Rest, with relief of symptoms, may be obtained by Reichert's "three pillow arrangement," described by Hendricks[5] As noted previously, procaine block of the scalenus anticus muscle may be used advantageously in the treatment. In spite of all these aids to the patient, many will not be relieved of their symptoms and must come to operation. We have also noted that patients with marked associated vasomotor changes in their upper extremities were greatly benefited by removal of the upper three dorsal sympathetic ganglions through the same approach at the time of removal of the cervical rib.

In our experience the results have been more satisfactory following removal of the rib at the initial operation, and we advise this procedure rather than simple division of the anterior scalenus in most instances.

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verse process of the seventh cervical vertebra, producing a sharp posterior spicule which was compressing the middle trunk, while the rib extended out anterior to the posterior cord and between the lateral and medial cords of the brachial plexus. The lateral fragment of the rib was 2 cm. long and was removed *in toto*. At the site of compression and irritation of the middle trunk, it was rough and red, with definite evidence of contusion, but no laceration was noted. The anterior scalene muscle was partially excised during the exploration. The motor power in the forearm and hand was good but abduction of the shoulder and arm was still markedly impaired according to the last report one year after operation.

CASE 3. This 47 year old white man noted a lump in the left supraclavicular fossa six to seven years prior to being seen at the Lahey Clinic. He had had an exploratory operation elsewhere and an enlarged pulsating artery was found, but no further surgical procedure was carried out at that time. He had no clinical symptoms until six months before admission when he began to notice that his left hand became cold and pale, particularly when reaching for something, carrying the arm over his head or when he put his hand in cold water. About this time he began to have pain in the supraclavicular region and down the medial arm into the hand. There was increased pulsation in the left supraclavicular mass which seemed to be getting larger. Two to three months before admission he noted that his hand was getting smaller and that his muscles were wasting away. On January 1, 1941, the patient was admitted to the New England Deaconess Hospital.

Examination revealed a pulsating supraclavicular mass about 3 cm. in diameter, with tenderness in this region, and a small, well healed scar in the skin over the mass The left hand was definitely colder and reddened as compared to the right. The radial pulse on the left was completely obliterated, while there was a good pulse on the right. On voluntary motion the patient complained of pain in the left arm. There was marked atrophy of the intrinsic muscles of the left hand, particularly in the hypothenar eminence. No sensory changes were found. Roentgenograms revealed bilateral cervical ribs which were fused with the corresponding first thoracic ribs at their anterior projections.

Thermocouple readings of multiple upper extremity points bilaterally revealed marked depression of the temperature of the left fingers, hand and antebrachium—variations being 10 to 15° F. below those on the right.

On January 7, 1941, an exploration of the anterior scalene muscle and cervical rib region was done through an anterior approach. The aneurysmal mass of the subclavian artery lay just distal to the lateral border of the scalenus anterior muscle. As soon as the muscle and fibrous band were freed there was some dilatation of the artery which had been under the scalenus anterior. There was a pulsation of the aneurysmal mass, but it must have been transmitted for no blood could be aspirated. The trunks of the brachial plexus were bound up in a peri-aneurysmal mass of scar tissue, and had to be partially dissected out so as to get at the aneurysm which was incised in linear fashion, and an organized clot removed after triple ligation of the proximal subclavian artery, distal to the thyrocervical trunk After removal of the clot the greater portion of the aneurysmal sac was excised and the remainder sutured to the clavicle to leave a smooth passage for the brachial plexus. The cervical rib was left in place as no evidence of pressure from this structure was seen. The pathologic report was subacute arteritis with mural thrombosis and peripheral granulation tissue.

Postoperatively, the patient did very well, but it was noted that the hand was pale and cold The radial pulse did not return. Accordingly, it was decided to perform an upper dorsal sympathectomy on the left. This procedure of freeing the connections of

MENINGIOMAS AND NEUROFIBROMAS OF THE SPINAL CORD

Certain Clinical Features and End Results

GILBERT HORRAX, JAMES L. POPPEN, W. Q. WU AND P. R. WEADON

The purpose of this communication is to present the experiences of the neurosurgical department of the Lahey Clinic in dealing with the benign, encapsulated tumors of the spinal cord during the past fourteen years. These tumors are the extramedullary, intradural meningiomas and neurofibromas (neurolemmomas) arising respectively from the meninges or from a spinal nerve root.

The first time that such a tumor was localized and removed operatively was on June 9, 1887.[5] The localization was made by Sir William Gowers, and the tumor was removed by Victor Horsley. The patient was completely cured. Since that date many individual case reports as well as reports of series of cases have been made, and the end results on the whole have been extremely favorable.[1-4, 6] Indeed, the results have often been dramatic, inasmuch as many individuals have recovered completely from paralysis of the lower extremities and have been relieved entirely of the severe pain which they were experiencing before the growth was removed.

The symptomatology of the tumors in question is too well known and has been so frequently discussed that it is not our purpose to dwell on this aspect in any detail. Suffice to say that pain following the course of a spinal nerve root is one of the prominent and early symptoms in a large number of patients, followed at varying intervals—weeks to years—by signs of spinal cord compression, paresthesia, increasing weakness of one or more extremities, and eventually paraplegia with bowel and bladder incontinence if the tumor is not recognized and extirpated.

The material from which the present data were derived was taken from the records of 60 patients from whom 61 tumors were removed and verified microscopically (1 patient had 2 tumors). The patients were observed between January 1, 1933, and November 25, 1947, the observation therefore varying from one to fourteen years. During this same period there were 157 spinal cord tumors of all types verified on the neurosurgical service, so that the meningiomas and neurofibromas represent 38.8 per cent of all the spinal tumors seen on the service.

Of the 61 tumors with which we are concerned, 37 or roughly 60 per cent were neurofibromas and 24 or roughly 40 per cent were meningiomas. The various levels at which the two types were found in the cord are interesting. The thoracic region was the most frequent site for both varieties, a total of 35 tumors, roughly 57 per cent, being located in this area, but whereas 18 or 48 per cent

Originally published in Surgical Clinics of North America, 29:659–665 (June) 1949.

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as if these severe symptoms have continued for one to five years their chanc great relief are extremely small, although even then some improvement ma expected.

OPERATIVE PROCEDURES

There are a few points which should be emphasized concerning the oper. removal of extramedullary spinal cord tumors. For this purpose we may sider the neurofibromas situated (*a*) on the posterior surface of the cord, lateral to the cord and (*c*) anterior to, that is underneath, the cord, and seco the meningiomas *which are attached to the dura, particularly along the la* wall of the spinal canal.

For all tumors of the types here considered, after they have been loca by neurologic measures combined with myelography when necessary, we lieve that a complete laminectomy should be performed covering the are question. As a rule this will mean the removal of the spines and lamina about four vertebrae in order to get adequate exposure above and below growth. Although some tumors are doubtless capable of removal using or hemilaminectomy, we believe that there is less danger of cord damage by ta off the laminae over both sides, and we have never seen any disability a utable to the bilateral procedure.

The bone having been removed by rongeurs in the usual way and the mentum flavum as well as the layer of fat over the dura likewise excised tumor may often be felt as a firm area by palpation of the dura if the gr lies on the posterior or posterolateral surface of the cord. There is also incre vascularity of the bone and of the dura at the level of the tumor, espe with meningiomas. The dura should now be opened by a median linear sion, and the edges of dura are conveniently held retracted by taking a few sutures through the dura and carrying the stitch out through the retr muscle, tying the silk so that the dura is held firmly reflected. As the du being opened it will be seen to be somewhat adherent to the surface of tumor, from which it must be carefully separated. It will likewise be seen there is little or no pulsation of the cord below the growth, whereas no pulsation is present above it.

When a neurofibroma lies on the dorsal surface of the cord the proble its removal is relatively simple. The delicate arachnoid membrane is easily sected away from the growth after which it may be mobilized by lifting up of its ends with a suitable instrument and carefully separating it from the to which it is only slightly adherent. A nerve root will be seen to enter the tu at some point and this root from which the growth arises should be di between silver clips, silk ligatures or after crushing the root with a hemosta

If the neurofibroma lies lateral to the cord and is not large enough to compressed the cord greatly it may often be "delivered" after freeing the a noid over it by lifting one end with a blunt dissector or by passing one or silk stitches through the end and using these to make traction on the tu (Fig. 425). Great care should be exercised, of course, not to let the gr make any added compression of the cord during delivery, and if there is question of this, especially if the tumor is plump rather than elongated, its

of neurofibromas were so situated, 17 or 70 per cent of the meningiomas involved the thoracic cord. The next most common site for neurofibromas was in the lumbar area, where there were 13, in contrast to one meningioma, and there were 6 of each tumor type in the cervical region.

The sex and age incidence in our group follow that reported by others. There were 20 males (2 tumors in one individual) and 40 females. The ages of the patients varied from 18 to 71 years.

The average duration of symptoms before operation was twenty-three months. There were 22 patients who had had symptoms for less than one year, whereas in 32 the symptoms had been present from one to five years. In 6 patients the duration was not given exactly.

MYELOGRAPHY

In addition to the history, neurologic examination and the usual lumbar puncture studies, it was deemed wise to do some form of a myelogram on 55 patients in order to localize the tumor with more exactness. For this purpose oxygen was used thirty times, lipiodol eighteen and pantopaque seven.

RESULTS

Of the total 60 patients, 44 or 73.3 per cent were either completely cured or so greatly improved that they were capable and useful citizens. Twelve others (20 per cent of the total) were somewhat improved over their preoperative condition, while 3 or 5 per cent were unimproved. There was one death in the series (a patient with recurrent tumor operated on elsewhere eight years previously), giving an operative mortality of 1.7 per cent.

It is of particular interest to compare the results of operation as correlated with the duration and the severity of the patients' symptoms.

1. *Symptoms for less than one year.* Among the 22 patients who had symptoms for twelve months or less, 9 had severe pain or weakness up to paralysis. Of these, 7 or 77 per cent (31 per cent of the 22) were cured or greatly improved, one was somewhat improved and one was unimproved. Of the other 13 who had only slight pain or weakness, 12 or 92 per cent (54 per cent of the 22) were cured or greatly improved and one was somewhat improved. Thus 85 per cent of all the patients in this group were cured or greatly improved.

2. *Symptoms for one to five years.* Here the story is quite different. There were 32 patients in this group. Ten of these had severe pain or weakness up to paralysis and none of them was cured or greatly improved. Eight were somewhat improved and 2 were unimproved Twenty-two of the 32 patients with long duration of symptoms had only slight or moderate pain or weakness. Of this number, 20 or 90.9 per cent (62.5 per cent of the 32) were cured or greatly improved, and 2 were somewhat improved.

It would seem to be a fair deduction from all these figures, therefore, that if a patient with the type of spinal cord tumor under discussion has only slight or moderate symptoms, he has a 90 per cent chance of being cured or greatly relieved by the removal of his growth no matter how long his symptoms may have been present. Furthermore, 75 per cent of those with severe symptoms, if these have been present less than one year, should be very greatly relieved, where-

as if these severe symptoms have continued for one to five years their chances of great relief are extremely small, although even then some improvement may be expected.

OPERATIVE PROCEDURES

There are a few points which should be emphasized concerning the operative removal of extramedullary spinal cord tumors. For this purpose we may consider the neurofibromas situated (*a*) on the posterior surface of the cord, (*b*) lateral to the cord and (*c*) anterior to, that is underneath, the cord, and secondly the meningiomas which are attached to the dura, particularly along the lateral wall of the spinal canal.

For all tumors of the types here considered, after they have been localized by neurologic measures combined with myelography when necessary, we believe that a complete laminectomy should be performed covering the area in question. As a rule this will mean the removal of the spines and laminae of about four vertebrae in order to get adequate exposure above and below the growth. Although some tumors are doubtless capable of removal using only a hemilaminectomy, we believe that there is less danger of cord damage by taping off the laminae over both sides, and we have never seen any disability attributable to the bilateral procedure.

The bone having been removed by rongeurs in the usual way and the ligamentum flavum as well as the layer of fat over the dura likewise excised, the tumor may often be felt as a firm area by palpation of the dura if the growth lies on the posterior or posterolateral surface of the cord. There is also increased vascularity of the bone and of the dura at the level of the tumor, especially with meningiomas. The dura should now be opened by a median linear incision, and the edges of dura are conveniently held retracted by taking a few silk sutures through the dura and carrying the stitch out through the retracted muscle, tying the silk so that the dura is held firmly reflected. As the dura is being opened it will be seen to be somewhat adherent to the surface of the tumor, from which it must be carefully separated. It will likewise be seen that there is little or no pulsation of the cord below the growth, whereas normal pulsation is present above it.

When a neurofibroma lies on the dorsal surface of the cord the problem of its removal is relatively simple. The delicate arachnoid membrane is easily dissected away from the growth after which it may be mobilized by lifting up one of its ends with a suitable instrument and carefully separating it from the cord to which it is only slightly adherent. A nerve root will be seen to enter the tumor at some point and this root from which the growth arises should be divided between silver clips, silk ligatures or after crushing the root with a hemostat.

If the neurofibroma lies lateral to the cord and is not large enough to have compressed the cord greatly it may often be "delivered" after freeing the arachnoid over it by lifting one end with a blunt dissector or by passing one or two silk stitches through the end and using these to make traction on the tumor (Fig. 425). Great care should be exercised, of course, not to let the growth make any added compression of the cord during delivery, and if there is any question of this, especially if the tumor is plump rather than elongated, its con-

tents should first be removed by curettage, after which the capsule may be withdrawn and gently separated from the cord and neighboring nerves. In all cases the nerve root from which the growth has arisen must be sacrificed, but even in the cervical or lumbar region this leaves only a minor sensory deficit, which in any case was doubtless present before operation.

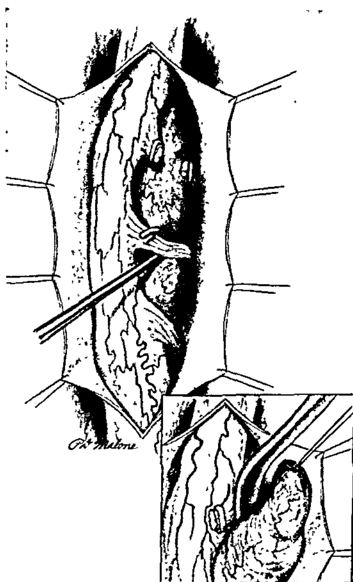


Fig. 425. Neurofibroma lateral to the cord. *Inset,* the upper end of the tumor lifted by traction sutures passed through it and the capsule freed from the cord by a smooth blunt dissector. One nerve root has been divided.

In rare instances when the tumor lies largely or wholly underneath (anterior) to the spinal cord its edge must be exposed by gentle retraction and then its contents must be very completely evacuated by blunt or sharp curets according to how soft or fibrous the growth happens to be. The capsule is then withdrawn without further contusion or compression of the cord. (Fig. 426). Some tumors will be seen to extend far out into or through an intervertebral foramen, and of course in this case they must be followed out as far as necessary to complete

their removal. There are occasional cases of "dumbbell" tumors in the thoracic region, one portion of neurofibroma being inside the spinal canal compressing the cord, and the other portion extending through an intervertebral foramen into the chest where it may attain large size. The intrathoracic portion must be removed by a secondary operation from an appropriate approach through the chest.

Meningiomas which involve the cord by pressure arise from the contiguous dura. Their operative removal in large measure follows the methods described



Fig. 426. Neurofibroma lying largely underneath (anterior) to the cord. *Inset*, the capsule of the tumor has been incised and its contents evacuated by spoon or curet. The capsule may then be withdrawn without further compression or damage to the cord.

for neurofibromas except that in addition to removing the tumor itself, its dural attachment must likewise be excised inasmuch as it contains tumor cells. This is accomplished by incising the dura above and below the tumor and carrying the incision completely around the attachment (Fig. 427). This offers difficulties on account of vascularity but silver clips may be placed along the edges as they are cut, or bleeding may be controlled by careful electrocoagulation, avoiding the use of the electric current when the dissection is too near the cord or spinal nerve roots. The dural defect should be covered with gelfoam.

After the removal of spinal tumors the cord over the whole area exposed should be covered with a thin layer of gelfoam and the dura closed with interrupted silk sutures about a quarter of an inch apart. The muscles should then

be closed with through-and-through stitches of heavy silk or silver wire after which several further layers of interrupted sutures of fine silk should be taken in the fascial layers and in the skin without drainage.

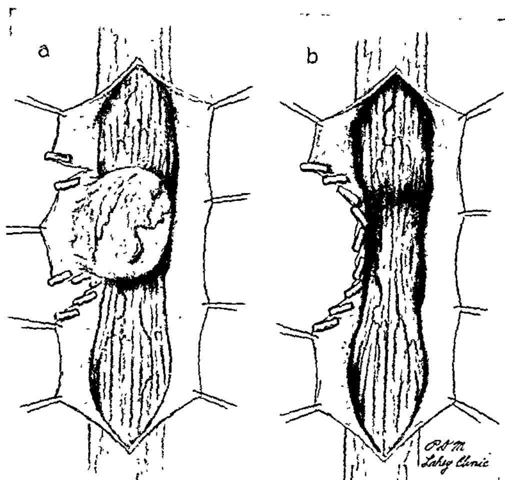


Fig. 427. Meningioma with its attachment to the dura lateral to the cord (*a*). This dural attachment must be excised with the tumor. Silver clips are placed along the vascular edges as the dura is incised (*a*, *b*).

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THE HERNIATED INTERVERTEBRAL DISK

400 Proven Cases 18 Months to 10 Years Following Operation

JAMES L. POPPEN

In the last ten years considerable material has appeared in publications indicating that the presence of herniated intervertebral disks is not a myth but a proved entity, producing a train of symptoms and signs that are as characteristic as are those of renal colic or appendicitis. As is so true of all new developments, there are always those who are overenthusiastic in the treatment of this disease and those who are skeptical about it.

It is astounding to find that so many proved ruptured disks have been discovered in such a comparatively short time. Inasmuch as it is known that this condition was present since man first assumed the upright position, and that many patients with the now characteristic group of symptoms of a herniated disk did quite well on conservative measures, one must wonder whether or not much of the surgical interference that is now instituted may not be superfluous or even unjustifiable. It is with this in mind that 400 operatively proved cases, in which eighteen months to ten years have elapsed since surgical intervention, have been studied.

An interpretation of one's results cannot be entirely unbiased, and what one surgeon would consider a good result may be judged a poor result by another. All factors must be weighed carefully, such as the personal factor—the surgeon, industrial surgeon, and employee—the discomfort and disability of the patient before operation as compared with his postoperative symptoms, the ability of the patient to carry out his usual occupation, and his wage-earning capacity. This survey was made on the assumption that most patients are honest, and therefore considerable reliance was placed on the patient's statements whether they considered the results satisfactory. If, however, a patient thought that the result was satisfactory but the facts indicated that he was not back at his usual occupation because doing so resulted in considerable low-back discomfort and necessitated frequent absence from work, this result was certainly not satisfactory from the industrial surgeon's or employer's standpoint. The patients were checked personally, but they were also requested to answer a questionnaire that gave additional information. In this manner it could be determined with reasonable accuracy whether the operative procedures instituted were justifiable in each case.

There can no longer be any skepticism concerning the presence of the herniated disk and its actual participation in the production of low-back pain and sciatica. There is, however, no question that the time and type of treatment to be instituted are still somewhat vague. For this reason one must not be too decided in his opinion about the proper treatment in a given case until a thorough

Originally published in New England Journal of Medicine, 232:211–215 (Feb. 22) 1945.

history has been taken and a complete physical examination, including a b and joint as well as a neurologic survey, has been made. The laboratory stu should include the usual blood and urine examinations, and roentgenogr of the lower spine and sacrum should be made. These studies usually rule the more frequent causes of low-back pain with sciatica, such as osteo-arth metastatic malignant bone lesions, angiomas of the bone, osteomyelitis, old c pressed fractures, Marie-Strumpell arthritis, diabetic neuritis, syphilis, postherpetic neuralgia—evidenced by segmental scars on the skin.

Spinograms should not be used in every case. Certainly, if all the studies h been normal, in the presence of a typical history of a herniated disk as wel typical neurologic findings, it is usually safe to carry out an exploratory op tion. Roentgenograms with a contrast medium (oxygen is used exclusively at Lahey Clinic) should emphatically be made, however, in the following four ty of case. The first group comprises patients who have severe sciatica that has responded to conservative measures in three weeks. If a large defect is present exploratory operation is indicated. If a small or no defect is present, one justifiably continue conservative measures. The second group includes thos whom either the history or the findings are atypical. The third group is compr of patients with low-back pain in whom a fusion is contemplated, unless ploration is to be carried out at the time of fusion. The fourth group is for of patients in whom roentgenograms of the lumbar spine show marked dege ating changes with spur formation.

The study of the 400 cases was instructive because of the fact that the histo were uniformly characteristic. The physical findings varied considerably, depe ing entirely on the time the patient was examined and whether the condition in an acute, subsiding or quiescent state. During the quiescent stage the findi in many cases were absolutely normal. Since, therefore, the patients were amined in varying stages, the percentages quoted in the findings must necessa be different from those if every patient had been examined only during acute stage.

CLINICAL DATA

Frequency. This series represents 8 per cent of the patients who entered clinic with the outstanding complaint of low-back pain, with or without sciat This emphasizes the point that even though the herniated disk is an import link in the chain of conditions that cause low-back pain and sciatica, it is by means the predominant one.

Etiology. It is of interest that 7 patients belonged to families several memb of which had had herniated disks. In one family there were two sisters and brother, in another, two brothers and sisters. A history of injury was given in per cent of the cases. It is significant that the usual account of injury was that a sudden lifting strain during which the patient felt a snap in the low back a immediately experienced either a numbness and tingling in one leg or a sudd severe, sharp pain. In many cases, however, the paresthesia or pain did not co on until several hours or days later. It is somewhat difficult to explain why ru tured cartilages do not follow severe injuries such as compression fractures dislocated fractures of the spine. It appears that actual rupture may take pl

into the crushed bodies rather than posteriorly, and that during the period of convalescence actual bony union takes place, incorporating the injured disk, and in that manner prevents later herniation.

There can be little question that rupture of disks occurs most frequently at the site of greatest mechanical stress and strain in both the cervical and lumbar regions. The fact that 68 per cent of the cases occurred in males and 32 per cent in females also tends to favor trauma, especially since 84 per cent of the cases occurred in patients between the ages of 20 and 50 and about equally divided in these three decades. Sixty-five per cent were manual laborers and 35 per cent professional workers. In only 6 per cent of the patients were there demonstrable anomalies, such as spina bifida occulta. Abnormally placed facets were frequent.

Subjective Symptoms. The duration of symptoms varied greatly. There was no accurate way of determining the actual time element, since in all the cases the symptoms tended to occur periodically, lasting from a few days to several months and occurring over a period of up to twenty years.

Recurrent low-back pain was present in 95 per cent of the patients. It preceded the sciatica in many cases and appeared simultaneously with the leg pain in the remainder, in some cases being located one or two vertebrae higher than the herniated disk. Sciatica was present in every case except 2, in which there was severe mid-low-back pain, coming on at intervals. Both patients proved to have midline ruptures without compression on separate nerve roots.

In 63 per cent of the patients the sciatica was unilateral. It must be emphasized that the pain must be in the sciatic distribution if the disk is at the fourth or fifth lumbar segment, and any pain that is not limited to it must be viewed with skepticism in the diagnosis of herniated disk. Nine patients had pain in the thigh due to herniated disks at the second or third lumbar segment. The exceptions to the rule hold true, however, and in this series 5 patients had associated severe pain in the inguinal region. Seventy-five per cent of the patients complained of pressure paresthesia Minor motor changes were noted in many cases. Paralysis, however, was the chief complaint of 6 patients. Fifty-two per cent of the patients complained of radiating pain into the leg on coughing or sneezing. Constipation was present in 47 per cent of the series, probably because straining at stool accentuated the leg discomfort. The fact that patients with herniated disks are usually more comfortable while lying down is important to remember, in contradistinction to those with cauda equina tumor, in whom pain is usually less in the upright position.

Objective Findings. The most constant objective finding was a positive straight-leg reaction, which was present in 90 per cent of the patients when the protrusion was at the third, fourth or fifth lumbar segment. It is safe to say that this test would be positive in nearly 100 per cent of patients if they were examined during an acute phase of the condition Certainly, if a patient is in a supposedly acute phase and a positive straight-leg reaction is not present, other pathologic factors should be suspected.

Seventy-five per cent of the patients demonstrated definite spasm of the low-back muscles Localized paraspinous tenderness was present in 80 per cent. Forty-eight per cent had sensory changes in the fifth lumbar or first sacral dermatomes or both. In 35 per cent, list of the spine occurred away from the site of the lesion.

In 45 per cent, atrophy of muscle groups—gluteal or calf—or of the extremity from disuse was noted. Fibrillary twitchings were present in 25 per cent. An absent Achilles reflex was noted in 43 per cent, being most frequent with herniated disks at the fifth lumbar segment.

The spinal-fluid studies showed an elevated total protein in only 53 per cent of the patients. Evidence of spinal-fluid block was found in only 2 per cent of the cases. This may be accounted for partly by the fact that in the early group the lumbar puncture was always made in the fifth lumbar space, whereas it is now usually made in the third lumbar space.

Roentgenograms of the lumbrosacral spine demonstrated a narrowed interspace at the site of the disk in 15 per cent of the series, localized arthritis (possibly traumatic) in 20 per cent, and an unstable lumbrosacral joint in 11 per cent. No characteristic finding indicating a herniated disk was noted in the routine roentgenograms of the spine. Narrowing of the disk space was not an assurance that a posterior dislocation of a disk was present. From these experiences, a normal roentgenogram of the low spine in the presence of a typical history and findings is an additional indication of the probable presence of a ruptured cartilage.

Potentially unstable lumbrosacral joints—abnormally placed facets—were present in 6 per cent of the cases. Congenital defects, such as spina bifida, occurred in 6 per cent, indicating at least that congenital malformation demonstrable roentgenologically was not an important factor in producing ruptured cartilages.

Treatment. The best treatment of herniated disks will remain a subject of debate for some years to come. Conservative surgeons will continue to treat patients much along the same lines as they have treated them in the past—by physiotherapy, immobilization, traction, epidural injections, manipulations and so on. The enthusiasts will, of course, operate on all patients who have symptoms. There are also those who will try to maintain a middle course, attempting to determine which patient should be treated conservatively, which should have simple removal of the disk, and which require a combined removal of the ruptured cartilage and fusion. It is the latter course that would be ideal. The only disadvantage about this position is that with the present knowledge there is no definite rule by which the proper treatment in each case can be determined, and there will not be until at least ten to fifteen years have elapsed so that the results of treatment can be adequately compared. Sufficient time has elapsed and an adequate number of patients have been treated, however, so that at least certain facts can be kept in mind when the decision concerning treatment is considered.

There is no question that operative procedures were instituted in some cases reported in this series in which conservative measures would have adequately taken care of the situation, but in no case was the condition made worse, except temporarily by postoperative discomfort. Certainly, one should consider the tolerance for pain and the disability of each patient, to decide whether the situation in all its details and findings is typical or atypical, and to make use of these interpretations in deciding on the form of treatment.

Any patient who has had repeated disabling attacks of sciatica necessitating narcotics and who in the previous few months has been unable to work because of a ruptured cartilage should, in my judgment, have operation. When a patient has had mild recurrences of symptoms causing considerable discomfort but not

severe enough to discontinue work at any time, he should just as certainly, in my opinion, be treated conservatively. In the latter case, if the neurologic examination shows considerable evidence of root compression, even though the pain is not severe, the patient should have the benefit of surgery.

In any patient who has been disabled with severe pain only for one or two days out of the year, and between attacks is normal, conservative treatment is justified. By conservative measures are meant physiotherapy in the form of heat, massage and postural exercises, rest in bed on a firm mattress and administration of large doses of betaxin intravenously for a few days. Betaxin is given in an attempt to relieve the associated mechanical radiculitis. Infiltration with procaine locally into the muscle is also of value.

When operation seems indicated, the question naturally arises whether fusion should be carried out at the time the disk is removed. It seems logical that any patient with predominating leg pain (sciatica) and with minor back difficulty whose roentgenograms show no bone changes should have only the disk removed if this is done through a small exposure, whereas in a patient who has predominating back pain, with definitely abnormal facets and evidence of an unstable back, and who has to do hard manual labor, removal of the degenerated cartilage with fusion is indicated With the latter state, the long initial hospital stay and inability to work may finally prove to be a shorter course in obtaining relief than would have been the case if the disk alone had been removed.

Adequate removal of all the degenerated cartilage should be done in all patients operated on for herniated disk. It is not sufficient to remove only the loose, fragmented portions.

Postoperative Course. The immediate postoperative course of the patient operated on for a herniated disk is usually smooth, the patient being allowed any liberty he wishes to take. There is no objection to having him stand beside the bed to urinate any time after he has recovered from the anesthetic agent. The back rest is adjusted to any position in which the patient is most comfortable. He is usually up on the seventh postoperative day. The time of getting out of bed after an operation for herniated disk is best left in some degree to the judgment of the patient. Some patients have considerably more discomfort than others and for varying lengths of time after operation. The most annoying postoperative symptoms that occurred in this series were severe spasms of pain in the low back, involving the muscles of the thighs as well These spasms frequently come on at night, lasting for several minutes and occurring three or four times during the night. They are controlled only by fairly large doses of narcotics. These pains usually occur on the fourth to the seventh postoperative day and last for several days. In 1 case they lasted for several weeks. The incision was reopened in 2 of 10 cases in which these spasms of pain occurred, but nothing was found to account for them except local postoperative swelling of tissue.

Infection occurred in 3 patients. Opening the incision widely and allowing adequate drainage as soon as the infection was noted, with liberal use of the sulfonamide drugs, brought about wound healing in a few days.

The shortest postoperative stay in the hospital was four days and the longest five weeks, the average stay was twelve days.

Late Results. The late results are analyzed in Table 1.

The relief of sciatica was satisfactory in most of the cases. Residual back discomfort on heavy lifting or sitting in a cramped position for many hours occurred in almost half the patients. This percentage was not materially altered in those who had also had fusions, who comprised 9 per cent of the series. It must be admitted that of the patients in whom fusion was performed the predominant symptom was low-back pain, even though associated with sciatica, and that the roentgenograms showed unstable facets with localized reaction at the level of the ruptured cartilage. Two patients complained of severe occurrences of low-back pain in whom spinograms demonstrated midline protrusions at the fourth lumbar space that were verified by exploration. Even though only low-back pain

Table 1. Analysis of Late Results

LATE RESULTS	PERCENTAGE OF SERIES
Relief of pain:	
Complete relief of pain	65
Complete reduction in sciatica	90
Reduction in symptoms:	
75 to 90 per cent	20
50 to 75 per cent	10
No relief	5
Return to usual activity:	
Returned in 1 to 3 months	30
Returned in 3 to 6 months	30
Returned in 6 to 12 months	35
No return	5
Unable to do heavy lifting without low-back discomfort	60
Able to do everything without discomfort	38
Complaint of low-back discomfort when tired	40

was complained of with no associated sciatica, simple removal of the ruptured cartilage was performed. One patient was completely relieved, the other has had no further severe pain necessitating bed rest, but has been unable to carry on his usual work in a foundry because of low-back discomfort.

The ability to return to work in their usual capacity is encouraging to these patients. This ability depends to some degree on the information that the patient is given before the operation. It must be made clear to him that just because he has had an operation on his back does not mean that it has been weakened and therefore he must be careful of it. Co-operation between the employer, surgeon and patient is highly important. It seems unwise to ask the patient to do a full day's work the day he reports for duty. One must keep in mind that these patients have not used the muscles that are ordinarily exercised in their work and therefore have to be gradually conditioned, just as in any athletic sport in which different groups of unconditioned muscles must be built up gradually. Permanent damage, both physical and mental, can be done by unintelligent conditioning by either the patient or the employer. For this reason postural exercises and physiotherapy are extremely important parts of the postoperative care.

In 15 per cent of the series the patients did not obtain relief, in the majority of cases this was not the result of recurrence. All patients who have persistent

leg pain, however, must be suspected of having either a recurrence in the same space or another disk rupture above or below the space where the ruptured cartilage was removed, or a persistent radiculitis. In a few patients posterior spur formation—so-called "eagle-beaking"—of bone from localized degenerative changes takes place, and if the nerve is not adequately decompressed, persistent leg pain will remain.

COMPLICATIONS

In discussion of this subject emphasis has been placed on the complications that may result from surgery. In competent hands, however, no serious sequelae should follow operation. There were no deaths or paralysis in any of the patients operated on in this series, even though in several cases a root segment was intentionally sacrificed in an attempt to relieve pain. In 1 case injury was unintentional. There were no demonstrable alterations except slight sensory changes in the lateral aspect of the foot and inability to spread the small toes.

It is important to emphasize what may happen if a patient who has a large ruptured cartilage remains untreated or is treated by nonsurgical methods. In replying to patients who inquired what would happen if operation was not undertaken, it was my original policy to say that so far as I knew, nothing would happen except that the periodic attacks of pain and incapacitation for work would persist for varying periods of time; that, after all, herniated disks had been present for many years in many cases, even though unrecognized except when causing paralysis, and that the present method of proving their presence and taking care of them had been in use only in the last decade. This advice and the logic back of it were unjustifiable, as indicated by the fact that in 6 cases in this series sudden complete paraplegia developed as a result of ruptured cartilage. Of these patients, 2 who had previously always been relieved by careful manipulation by competent osteopaths developed the paraplegia immediately following manipulation; 2 were manipulated by highly competent bone and joint surgeons and were paralyzed when they awakened from the anesthesia; 1 made a sudden misstep and developed an immediate cauda equina-paralysis syndrome, and 1 gradually developed a cauda equina-tumor syndrome with complete paralysis. In the last case, operation revealed a large disk with an associated adhesive arachnoiditis that completely obliterated the lumbar canal. Even though the protruded cartilages were removed in a relatively short time following the paralysis, many weeks and months elapsed before complete function returned. In 2 of these 6 patients five years after removal of the herniated disk, there is still a marked residual that prevents normal activity.

SUMMARY*

Four hundred proved cases of ruptured intervertebral disk in one or more spaces have been analyzed on the basis of objective and subjective symptoms, and the results eighteen months to ten years after operation have been presented Hence, no reference to the literature has been made.

* This article comprises an analysis of a series of cases seen in a single clinic over the course of ten years and comparative opinions concerning diagnosis and treatment have purposely not been discussed.

RELIEF OF ANGINA PECTORIS BY SYMPATHECTOMY

Report of Results in Ten Patients Subjected to High Thoracolumbar Sympathectomy Including the Anginal Pathway

JAMES A. EVANS, JAMES L. POPPEN AND JAMES B. TOBIAS

In April 1948 Evans and Bartels,[1] in reviewing the results of high thoracolumbar sympathectomy for essential hypertension, expressed dissatisfaction with the fact that anginal pain had been relieved in only 11 (73 per cent) of 15 patients subjected to the usual resection (fourth thoracic to second lumbar ganglions) of Poppen. For patients with severe angina we resolved in the future to remove a greater part of the anginal pathway which had been demonstrated by White, Garrey and Atkins[2] in the dog to include the first four thoracic sympathetic ganglions. Removal of these ganglions had been performed by Lindgren and Olivecrona[3] in 71 patients with angina pectoris, not all of whom had hypertension, with complete relief of pain in 44 per cent and partial relief in 41 per cent. White and Bland[4] reported that their results in 8 patients, 2 of whom had hypertension, showed that "resection limited to the upper three thoracic ganglions is nearly certain to afford complete relief of pain on the side of operation." Klemme[5] believed that his experimental work in dogs showed that the first thoracic ganglion could be spared and relief of anginal pain and coronary vasospasm achieved by removal of only the second through the fifth ganglions on the affected side. He reported one case in which this had been true.

Our own experience that a large percentage of hypertensive patients obtain relief of anginal pain without having resection of even a part of the so-called anginal pathway has been borne out by others. Peet,[6] reporting operations to the eighth thoracic ganglion as the upper level, stated· "Angina pectoris, either in a mild or severe form, occurs commonly in hypertensive patients. It may be the result of simple coronary spasm but in many it is probably due to actual arteriosclerosis of the coronary vessels Particularly . . . when the hypertension is of long duration . . . the patient with anginal attacks has certainly a much graver prognosis. Fortunately many patients with angina pectoris have complete relief following splanchnicectomy"

Peet reported two cases of angina; one patient obtained relief for ten years, the other had coronary occlusion before operation but no pain for five years after surgical intervention The same author again wrote[7] that resection to the seventh or eighth thoracic ganglion gave striking relief of anginal pain and palpitation. Some patients were completely relieved. In a few instances the electrocardiogram again became normal.

Peet[8] affirmed his belief that resections of the sympathetic chain to an upper

Originally published in Journal of American Medical Association, 144:1432–1436 (Dec. 23) 1950.

level of the eighth thoracic ganglion together with splanchnicectomy help angina by relieving strain. He entirely relieved 14 patients of angina for five years. Of 68 patients with hypertension who had angina, 42 (62 per cent) survived five to twelve years, and half of these, or 31 per cent, obtained definite relief, 14 patients had complete relief of angina for five years or more. None of Peet's operations involved the anginal pathway.

During the course of several years, Grimson[9] performed so-called total sympathectomies on 133 hypertensive patients. This operation includes the anginal pathway. All but two of 33 patients with precordial pain in this group of 133 hypertensive patients were relieved. He stated: "Since the operation interrupts both nervous pathways conducting pain from the heart and sympathetic cardiac accelerators, elimination of these complaints is expected in all cases. The exceptional persistence in the few might be explained by error in subjective observations."

Smithwick[10] corroborated Grimson's observation in a group of 15 hypertensive patients with angina on whom he performed thoracic sympathectomy and splanchnicectomy to the level of the first thoracic ganglion.

OBSERVATIONS ON THE ANGINAL PATHWAY

The so-called anginal pathway is well accepted as passing through the inferior cervical ganglion (first thoracic) and those ganglions below it, including the fourth thoracic (Fig. 428). The early resections of the cervical ganglions as pioneered by Jonnesco[11] proved failures because, as now known, direct fibers pass from the cardiac plexus to the second and third thoracic ganglions. According to White and Bland[4] the afferent pain fibers stimulated by cardiac anoxia and running in the middle and inferior cardiac nerves are all concentrated through the inferior cervical ganglion or stellate ganglion and the first thoracic ganglion usually fused with the stellate. There are also direct connections from the cardiac plexus passing through the second and third thoracic and probably the fourth thoracic ganglions.

It is not certain, according to White, whether pain fibers from the heart pass through the fourth thoracic ganglion. We are inclined to believe that they do because by extension of the resection level in splanchnicectomies for hypertension with angina pectoris from a point below the fourth thoracic ganglion invariably to include this ganglion the relief of anginal pain was raised from 12.5 to 73 per cent. This notable increase in satisfactory results cannot be the result *solely* of relief of the cardiac load from drop in blood pressure or of prolonged rest after operation. White and Bland[4] noted one case in which it was necessary to resect the fourth thoracic sympathetic ganglion on the left before a good result was obtained. In contrast, one of our patients who was subject to anginal attacks from whom the second and third thoracic ganglions were removed bilaterally for Raynaud's disease and scleroderma continued to have attacks of pain in the left arm although the substernal component was completely relieved. Removal of the fourth thoracic ganglion in this patient was not necessary, therefore, to abolish substernal pain. It would appear that the persistent pain in the left arm in this patient is mediated through the first left thoracic ganglion. This case is not included in the reported series because the patient did not have hypertension and

the operation was not purposely designed to relieve the angina, the fear being entertained at that date of robbing her of warning anginal pain. Two similar cases are included in the series; in these the left arm pain persisted when the first

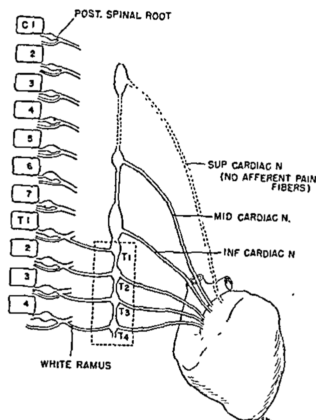


Fig. 428. The cardiac afferent pain pathway. Note how the anginal pathway is funneled through the first, second, third and fourth thoracic ganglions.

thoracic ganglion on the left was not resected. However, left arm pain did disappear in three patients whose first thoracic ganglions were left untouched.

Table 1. Results in Relation to Height of Resection

COMPLETE RELIEF			PARTIAL RELIEF		
Case	Left	Right	Case	Left	Right
2	T_1	T_3—Throat	1	T_3	T_6—Left side of neck, fingers
4	T_2	T_2	3	T_3	T_1—Left arm, throat (seldom)
8	T_1	T_1—Throat, jaw	5	T_2	T_4—Substernal pain on moderate exertion; complete relief of status anginosus
9	T_2	T_3—Throat	6	T_2	T_1—Hot sensation in arms, throat
10	T_1	T_4	7	T_2	T_4—Left side of chest, throat (mild)

Complete relief of anginal pain was obtained in five patients, four of whom had the first thoracic ganglion on the left resected. In two of these patients not

even throat pain occurred after operation. The weight of evidence, therefore, seems to indicate the importance of including the first thoracic ganglion in order that the patient may obtain complete relief. The recurrence of pain on the right in two patients leads us now to advise bilateral resection to the first thoracic sympathetic ganglion. This decision is consistent with the well recognized anatomic facts as demonstrated by White and Bland[1] and previously in animal experiments by White, Garrey and Atkins.[2]

As we embarked gradually on these procedures, our hesitancy to carry resection immediately up to the stellate ganglion was caused by the desire to avoid ptosis.

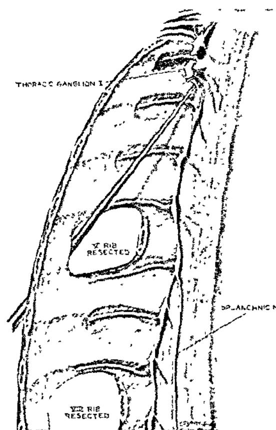


Fig. 429. The upper end of the sympathetic resection.

In some cases it is difficult to avoid resection of part of the stellate ganglion and the production of a Horner's syndrome if fusion of the first thoracic with the stellate ganglion is too close. None of our patients complained who did obtain a ptosis, however, and it has been our observation that in time the ptosis becomes less decided The fact that the higher the resection the better the results is also borne out by a comparison of results to the height of the resection. This is especially true on the left side.* Table 1 makes this evident.

TECHNIC OF OPERATION

The technic used for the removal of the stellate ganglion and the thoracic sympathetic ganglion chain is identical to the procedure previously described[12] for

* These operations being splanchnicectomies for hypertension, it is to be understood that the lower end of resection was the second or third lumbar ganglions bilaterally.

extensive combined thoracolumbar sympathectomy, except that the incision is extended cephalad approximately 4 cm. The medial portion of the fifth rib is removed as well as the eighth and eleventh ribs instead of the seventh and eleventh ribs as previously described. This allows excellent extrapleural exposure of the upper thoracic sympathetic chain and ganglions as indicated by Figure 429. The entire thoracic sympathetic system including the stellate ganglion may be removed in this manner (Fig. 430).

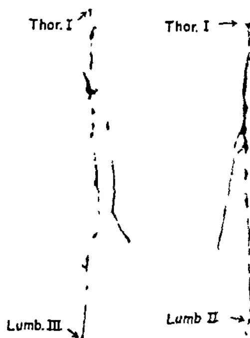


Fig. 430. Specimens removed in sympathectomy from the stellate ganglion to the third lumbar ganglion (hypertension with severe angina).

GENERAL RESULTS

High thoracolumbar sympathectomy (Table 2) was performed in a series of 10 hypertensive patients with severe disabling angina pectoris, among whom only one had had probable coronary infarction (Case 8) but all presumably had coronary insufficiency. The follow-up period was from three months to three years. Complete relief except for a residual sensation of constriction in the throat was obtained in five, or one half of the cases. There was partial but satisfactory relief of pain in the remaining five patients. One of the latter group, referred to Dr. Poppen for operation by Drs. Joslin and Root, was bedridden with status anginosus. Merely turning in bed produced pain. Although she still suffers mild substernal pain, causing her to stop to rest, she is active, doing all her housework and going on shopping trips (Case 5).

In Table 3 is listed the progressive relief of anginal pain in successive reports from the Lahey Clinic on results of splanchnicectomy for hypertension.

The patients in Series 4 all had severe disabling angina. Milder angina has so often been relieved by resection to the fourth thoracic level that we have not subjected these patients to resection of the first thoracic ganglion with its additional technical difficulties and danger of ptosis.

Table 2. Summary of Cases

CASE	AGE	SEX	PREOPERATIVE STATUS	LEVEL OF OPERATION	TIME OF FOLLOW-UP	PRESENT STATUS	RESULT
1	42	F	Grade 3 hypertension; pain in right chest and arm on exertion	Left: T_3-L_2 Right. T_6-L_2	3 yr. . . .	Experienced immediate relief of pain, but it recurred on the right, died 9/11/49 of coronary occlusion	Partial relief
2	46	F	Grade 2 hypertension, substernal pain on exertion	Left T_1-L_2 Right. T_7-L_3	3 yr. . . .	No angina	Complete relief, except throat
3	47	F	Grade 2 hypertension; exertional anginal pain	Left. T_3-L_2 Right. T_1-L_2	2 yr., 8 mo.	Occasional pain in throat and left arm on exertion	Partial relief
4	41	M	Grade 3 hypertension; substernal pressure on exertion	Left: T_2-L_2 Right: T_2-L_2	2 yr., 9 mo.	No angina	Complete relief
5	49	F	Diabetes mellitus; grade 3 hypertension; angina decubitus and status anginosus	Left T_2-L_2 Right: T_4-L_2	2 yr., . . .	No longer bedridden but has substernal pain on exertion and on standing quickly, complete relief of status anginosus	Partial relief
6	42	M	Grade 3 hypertension; persistent angina of effort despite previous T_7-L_1 resection	Left: T_2-T_9 Right: T_1-T_7	20 mo. . . .	No precordial pain but an occasional hot sensation in throat and arms	Partial relief
7	49	F	Grade 2 hypertension, substernal smothering, pain on exertion	Left: T_2-L_2 Right: T_4-L_2	15 mo. . . .	No angina for 1 yr. but in last 3 mo. return of some chest pain on exertion and choking sensation in throat	Partial relief
8	54	F	Grade 3 hypertension, substernal pain on exertion	Left: T_1-L_2 Right T_1-L_2	1 yr., 4 mo.	No angina; bilateral subacute subacromial bursitis developed	Complete relief, except throat and jaw
9	45	M	Grade 2 hypertension; bilateral Dupuytren's contracture; angina of effort	Left. T_1-L_3 Right· T_3-L_2	*6 mo.* . . .	No pain, only a sense of constriction in throat on exertion; Dupuytren's contracture better on left, worse on right	Complete relief, except throat
10	44	F	Grade 2 hypertension; dull, squeezing, substernal pain on exertion	Left. T_1-L_2 Right: T_4-L_2	3 mo. . . .	No pain	Complete relief

In Series 1 patients with anginal pain were not selected for surgical treatment. In Series 2 and 3 no careful note was made of whether the patient still had partial or complete relief. The pattern of the pain when it did recur was never noted as having been changed, as it invariably is when all or part of the anginal pathway is resected. There was no operative mortality in the 10 patients in Series

Table 3. Comparison of Relief of Anginal Pain in Four Series of Cases

	NUMBER OF PERSONS WITH ANGINA	HEIGHT OF RESECTION	SATISFACTORY RELIEF, PERCENTAGE
Series 1	0	T_{12}-L_2 or L_3	(Angina patients were avoided)
Series 2	8	Between T_{12} and T_5-L_2	12 5
Series 3	15	T_4	73 0
Series 4	10	Various parts of anginal pathway	100 0

4. One patient died three years later of a coronary infarction (Case 1). One other patient has survived three years, and three have survived two years.

COMMENT

All our patients had fairly severe symptoms of postural hypotension for about six months postoperatively, but only the most severely ill patient, who had status anginosus (Case 5), experienced angina on standing up quickly. Resection in this case was limited to the second thoracic ganglion on the left and the fourth thoracic ganglion on the right. It might be expected that decreased coronary flow resulting from rapid severe drop of blood pressure on standing would increase the incidence of angina in the hypertensive patient. The fact that this seldom occurs is an argument in favor of the possibility that abolition of the cardiac sympathetic pathway actually increases coronary flow. The principle of the reflex sympathetic dystrophy type of pain and the theory of the internuncial pool of Lorente de No[13] may account for the success of the operation. That some such mechanism may pertain is further borne out by the improvement of a Dupuytren's contracture in the left hand of one patient (Case 9) in whom resection was carried out to the first thoracic ganglion on the left, while the Dupuytren's syndrome on the right hand became worse when resection was only to the level of the third thoracic sympathetic ganglion. Kehl[14] reported six cases of Dupuytren's contracture following coronary disease and infarction. We suggest that good results might be expected in cases of the shoulder-hand syndrome, a rather rare complication of coronary artery disease described by Hilker.[15] Johnson[16] reported that hand changes take place in 21.8 per cent of patients with myocardial infarction, suggesting a reflex sympathetic dystrophy induced by cardiac pain. These observations enhance the rationale of sympathectomy for anginal pain.

Another disadvantage of the operation besides the ptosis of Horner's syndrome,

postural hypotension and severe sweating in the groins is swollen nasal membranes (noted by Grimson and others[9]). This last complaint occurred in two of our patients, but it tends to subside early.

That coronary irrigation may actually be increased in much the same way as in a desympathectomized limb is suggested by the increased capacity of these patients for work, before the residual throat constriction symptom of angina occurs. For example, in Case 8 the patient had hypertension Grade 3 and probably remote anterolateral myocardial infarction. For the past eighteen months she had been incapacitated and unable to do any housework or to walk in cold weather. Sixteen months after resection of the first thoracic to the second lumbar sympathetic ganglions on the left and the third thoracic to the second lumbar ganglions on the right she reported a new sensation of pain in the throat, radiating to both lower jaws. This pain was so unfamiliar to her and so different from her old angina pain that she attributed it to a small, nontoxic, colloid, adenomatous goiter and thought its removal might help. Only on careful questioning did it become apparent that this pain also occurred on effort but only after much greater exertion than that required to cause pain before operation. In fact she now does all her housework and goes shopping in any weather. Her blood pressure was still 230 mm. systolic and 110 mm. diastolic as compared to 250 mm. systolic and 124 mm. diastolic before operation. It was almost one and a half years after operation; she had had no intervening coronary attacks, so the extended exercise tolerance could not be attributed to reduction of cardiac load, prolonged rest after operation or the relief of effort angina that sometimes comes after a coronary infarction. White and Bland[4] have successfully abolished residual jaw pain by mandibular nerve injection.

Another possible argument in favor of increased coronary flow after desympathectomizing the heart is seen in Case 3. This patient's electrocardiographic exercise tolerance test changed from positive to negative. She wrote in her letter "I feel much better, do more work, have adopted a baby and am kept very busy." She still has occasional pain in the throat and left arm on exertion two years and eight months after resection of the third thoracic to the second lumbar ganglions on the left and the first thoracic to the second lumbar ganglions on the right.

The disappearance of the throat constriction together with all pain in two patients is probably the result of extension of exercise tolerance incident to increased coronary flow rather than of resection of any pain pathway mediating a sense of throat constriction.

In Case 1, in which the patient died three years after operation, results were the poorest of all, unfortunately the patient had resection only to the sixth thoracic ganglion on the right, although her pain preoperatively was mostly right-sided. Sweating could be demonstrated over the right side of the chest and the right arm after operation, proving that the most important pathway in this case was not touched at all. Our experience with this patient bears out White's[4] contention that cardiac pain is mediated to the right by the right cardiac nerves and to the left by the left cardiac nerves.

Case 6 is of interest because the patient had resection to the seventh thoracic ganglion in 1943 but still had angina. When he underwent operation again for

angina and persistent hypertension he obtained gratifying relief from resection to the second thoracic on the left and the first thoracic on the right.

In Case 7 the patient is classed as obtaining partial relief although she had complete relief for a year. Her recurrence in the last three months may be due to regeneration of the neural pathways, but she has not yet been subjected to a sweat test to determine this point.

CONCLUSIONS

1. Resection of various parts of the sympathetic anginal pathway (first to the fourth thoracic on the right and left) resulted in satisfactory relief of anginal pain in all 10 patients. Relief was complete in five except for a residual sense of throat constriction in three.

2. Resection of the anginal pathway should include the first to the fourth thoracic ganglions on both sides for best results.

3. There is not always residual throat or jaw pain, but relief from this may result because (*a*) exercise tolerance is improved by lessened strain on the heart from hypertension and (*b*) actual dilation of the coronary bed occurs.

4. The pernicious circle of anginal pain in status anginosus can be broken by sympathectomy, probably on the same basis that reflex sympathetic dystrophy is helped.

5. Horner's syndrome is not a valid contraindication to carrying the resection to the lower stellate ganglion (first thoracic), especially when the resection is bilateral.

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EXTENSIVE COMBINED THORACOLUMBAR SYMPATHECTOMY IN HYPERTENSION

JAMES L. POPPEN

In many instances, prolonged lowering of the blood pressure occurs in well selected cases following extensive thoracolumbar sympathectomy. It has been my experience that the fall in blood pressure with the patient in the horizontal position does not depend entirely on the extensiveness of the sympathectomy. The postural effect on the blood pressure, however, depends on the completeness of denervation of the splanchnic area. Therefore, to obtain effects immediately, or for a period of three or four months, it is not necessary to deviate from the technic of either the supradiaphragmatic approach used by Peet[4] or the subdiaphragmatic approach employed by Adson.[1] Smithwick[6] demonstrated to his satisfaction that extensive removal of the sympathetic nervous system was necessary to maintain a prolonged lowering of blood pressure. In 1938, he devised an operation permitting him to combine the supradiaphragmatic approach of Peet[4] with the subdiaphragmatic operation of Adson[1] by the removal of the twelfth rib and incising the diaphragm, thus allowing exposure for a more complete splanchnic denervation. Grimson,[3] in 1941, described a technic for complete thoracic and partial to total lumbar sympathectomy.

In my experiences since 1934 with the surgical treatment of hypertension, the technic advised and so adequately demonstrated by Peet[4] was first employed. Later, the subdiaphragmatic approach was used as advocated and devised by Craig and Adson.[2] In 1938, the latter technic was combined with a unilateral nephro-omentopexy. Since 1940, by a gradual evolvement the thoracolumbar sympathectomy has become more and more extensive.[5]

It has been shown by many investigators* that regeneration of the sympathetic nervous system is most difficult to retard. That this is true is illustrated by special tests on 2 patients whose drop in blood pressure was considered good for a period of two years following operation. The preoperative blood pressure levels and the complaints of severe headaches returned, however, after the two years had elapsed. These patients were subjected to further removal of the sympathetic nervous system, with good results It has been my experience that if an immediate drop in blood pressure does not occur within a reasonable length of time following operation, more extensive removal of the sympathetic nervous system will not be beneficial. Therefore, subjecting hypertensive patients to more extensive sympathetic denervation is justified only in patients who have had relief

Originally published in Surgery, Gynecology and Obstetrics, 84 1117–1123 (June) 1947.

* Dr. Kurt Richter, of Johns Hopkins Hospital, has studied many of our patients at varying intervals after operation from the standpoint of skin resistance.

of symptoms for six months or more, whose previous complaints then returned and the blood pressure became elevated.

Since neither the mortality nor the morbidity is increased by the technic that is employed at the present time, the added assurance that a more complete denervation has been accomplished makes the procedure a justifiable one.

The operation is performed in two stages at approximately ten-day intervals. The position of the patient during operation is of the utmost importance in facilitating the procedure. A lateral semiprone position is used (Fig. 431) with the thoracic spine flexed forward to as great a degree as possible. Flexion aids in making the upper dorsal ganglia more accessible. Either a combination of high spinal anesthesia, reaching up to the fourth thoracic level, and a light intravenous



Fig 431. *Photograph showing the lateral semiprone position of the patient and the site of previous incision.*

pentothal anesthesia, or the combination of pentothal, curare, and nitrous oxide is used. It is absolutely necessary to have adequate oxygenation throughout the operation.

The incision is made paravertebrally over the thickest portion of the long muscles of the back at the line of cleavage of the longissimus dorsi and iliocostalis dorsi muscles. It extends from the level of the seventh rib, curving very slightly anteriorly, to the distal portion of the twelfth rib (Fig. 432). The longissimus dorsi and iliocostalis dorsi muscles are separated over the medial portion of the eleventh rib as well as over the seventh or eighth rib. The seventh rib is removed if the dorsal spine cannot be flexed, as is the case in a few straight backed individuals. If the dorsal spine can be flexed readily, experience has demonstrated that the fourth dorsal ganglion can be removed more easily through the eighth than through the seventh rib. The medial portions of the eleventh and the seventh or eighth ribs are then removed for a distance of approximately 4 cm. from the transverse process, care being taken that the rib is not removed farther laterally than the width of the iliocostalis and longissimus dorsi muscles so as to

prevent deformity. Removal of as much of the rib vertebrally as possible allows more adequate exposure.

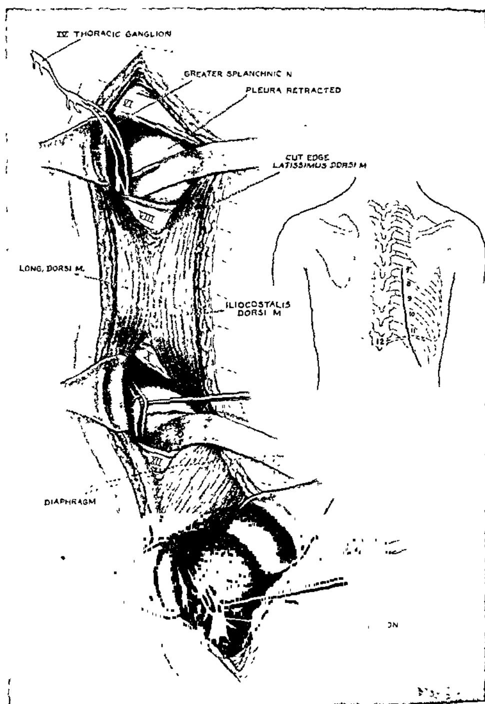


Fig 432. The incision is outlined in the insert. The approach to the thoracic chain with its branches is made by removal of segments of the seventh or eighth and eleventh ribs by separating the iliocostalis and longissimus dorsi muscles. The long deep muscles of the back are retracted toward the spinous processes below the twelfth rib, thus allowing the retroperitoneal space to be entered by incising the transversalis fascia

Considerable care should be taken to enter the proper line of cleavage between the parietal pleura and endothoracic fascia. When the line of cleavage has been established, it can be followed medially with a semisharp *Hedblom periosteal* elevator to the anterolateral border of the bodies of the vertebrae where the

greater splanchnic nerve lies. The index finger may then be inserted into the space and the line of cleavage followed cephalad and caudad through the open-

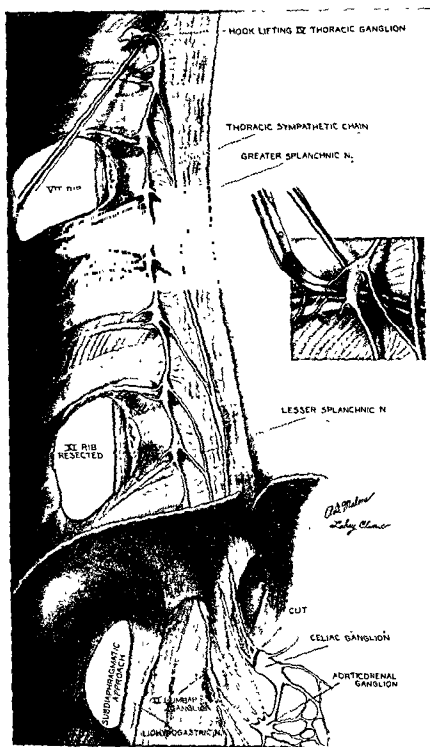


Fig. 433. The inset demonstrates the separation of the ganglion from the intercostal vessels *before the rami* communicantes are divided. The drawing allows visualization of the entire splanchnic distribution from the inside and its *relationship* to the apertures through which the removal is accomplished.

ings of the seventh or eighth and the eleventh ribs. Caution must be exercised at this point that the palmar surface of the index finger is kept firmly against the

endothoracic fascia rather than against the parietal pleura as the line of cleavage is being followed to prevent rupture of the parietal pleura. It is needless to emphasize that *opening of the pleura should be avoided if at all possible* since a relatively quiet anatomical dissection is immediately transformed into a more

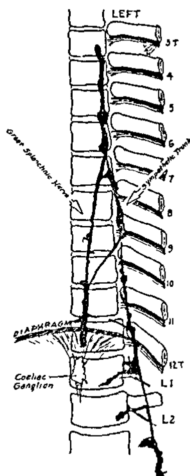


Fig 434.



Fig. 435.



Fig. 436

Fig. 434. Photograph of an actual specimen placed on a schematic drawing of the corresponding thoracic and lumbar vertebrae. Demonstrates the variation in the size of the ganglia as well as the fact that each ganglion may not have an individual connection with the greater splanchnic.

Fig. 435. Photographs of the actual surgical specimens showing the greater splanchnic arising from the thoracic ganglia by individual fibers. *a*, Demonstrates how two ganglia, in this instance the ninth and tenth, send joint fibers to the greater splanchnic as well as a separate branch from the thoracic trunk between them.

Fig 436 Demonstrates the splanchnic arising from the fifth thoracic ganglion, *a*, and from the sixth thoracic ganglion, *b*.

difficult and somewhat noisy procedure if the pleura is opened. Even though considerable care has been used, the pleura has been opened in 5 per cent of operations. The mere opening of the pleura may not be disastrous or cause more than relatively minor difficulties at the time the operation is performed. If by chance a postoperative infection should take place, however, one must necessarily deal with an empyema This certainly is adequate reason to avoid studiously opening the pleura. Anesthesia can be of great assistance in preventing injury to the pleura by the control of the depth and rate of the respirations.

After the pleura has been separated paravertebrally cephalad to the level of the fourth thoracic ganglion and caudad to the attachment of the diaphragm, the greater splanchnic nerve is mobilized along its entire length. The greater splanchnic nerve is mobilized first because it is in a relatively avascular bed. With the patient in the semiprone position, if slight oozing should take place at the time the ganglia are mobilized and their respective rami divided, blood gravi-

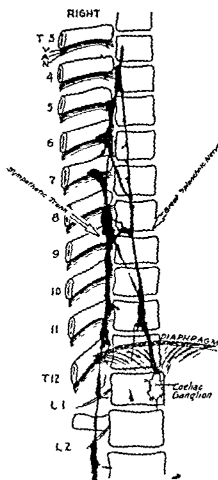


Fig 437. Demonstrates separate ganglia in the greater splanchnic; also the greater splanchnic arising from the fourth thoracic ganglion.

tates toward the mediastinum. If the greater splanchnic nerve were separated after the ganglia had been mobilized, possibly it would be obscured by blood-stained tissue.

Great care is taken in mobilizing the delicate nerve fibers that make up the greater splanchnic nerve from the individual ganglia (Fig. 433). It is surprising to note the difference in the size of the individual ganglia as well as the fact that some of the ganglia do not have individual fibers leading from them to the greater splanchnic nerve (Fig. 434). In a few instances connecting fibers lead directly from the thoracic trunk to greater splanchnic nerve (Fig 435, *a*). The main trunk of the splanchnic nerve usually arises from fifth or sixth ganglion (Fig. 436), but in several patients it has arisen as a separate trunk from as high as the fourth ganglion (Fig. 437) The nerve itself may have one to several ganglia or may have none.

After the fourth thoracic ganglion has been mobilized, the trunk is divided above it. The entire mobilized upper sympathetic trunk and its branches are then pulled down through the aperture made by the removal of the eleventh rib, care being taken that the entire system is kept in continuity so that there can be no question or possibility of leaving any ganglia, or any fibers that lead to the thoracic aorta. Care must be taken that the thoracic ganglia are separated from the intercostal nerve and artery before dividing the rami to avoid unnecessary

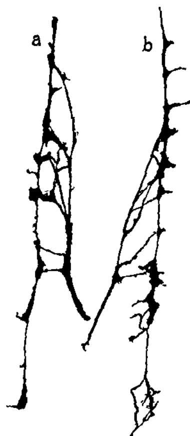


FIG. 438. The more common appearance of the thoracic and lumbar ganglia with their splanchnic branches; also the aorticorenal from the first and second lumbar.

bleeding (Fig. 433, inset). All bleeding, even from a larger intercostal artery, can readily be controlled by the electrosurgical unit.

It has been my experience that the dissection is less difficult if the thoracic *trunk is not divided until the desired number of ganglia that are to be removed* have been mobilized.

After the thoracic ganglia and trunk, as well as the splanchnic nerve, have been completely mobilized in continuity to the diaphragm, the iliocostalis and longissimus dorsi muscles which are called the sacrospinalis muscle at the level of the twelfth rib, are retracted medially toward the spine. This permits the lumbodorsal fascia as well as the transversalis fascia to be incised, care being taken during the dissection that the iliohypogastric nerve is not injured. The retroperitoneal space is then entered and the soft tissues retracted anteriorly. The greater splanchnic nerve can be readily identified as it emerges through the diaphragm, usually through a hiatus of its own (Fig. 433), although it may

emerge through the aortic hiatus. The greater and lesser splanchnic nerves emerge through the same aperture in many patients; however, in others they emerge through a separate aperture in the diaphragm. The greater and lesser splanchnic nerves are then detached from the celiac ganglion. The lesser splanchnic nerve usually has fibers entering the celiac ganglion and smaller fibers entering the aorticorenal ganglion (Fig. 433). In the female, the third lumbar ganglion is mobilized and the trunk immediately beneath it divided. In many instances fibers may be seen extending from the third lumbar to the aorticorenal ganglion or directly to the abdominal aorta. In other patients none may be found. The second lumbar ganglion always has a few fibers leading to the aorticorenal ganglion, the first usually having a fairly sizable trunk or at times several small strands of nerve leading to the aorticorenal ganglion (Fig. 438, *b*). The rami of the second lumbar ganglion are then divided; the crux of the diaphragm usually covers a part of the first lumbar ganglion. With the distal end of the lumbar trunk kept under slight tension, the crux of the diaphragm is incised and the first lumbar ganglion readily exposed and its rami divided. The incision through the crux of the diaphragm is then increased for a distance of several millimeters so that the aperture in the diaphragm is of sufficient size to permit the ganglia to be pulled through it from above. The mobilized cephalad end of the thoracic trunk and the splanchnic nerve are then grasped with forceps and by gentle traction the subdiaphragmatic portion of the greater and lesser splanchnic nerves, as well as the lumbar trunk, can readily be brought through the diaphragmatic aperture. In this manner the entire system is kept in continuity and there can be no question as to the completeness of the procedure.

Photographs are taken of the specimen so that they may be used for future reference. If, for instance, unusual areas of excessive perspiration develop in a supposedly denervated area, one can refer to the photograph and determine whether or not the ganglia involved were actually removed. In this manner one can determine, also, at a later date how much regeneration actually takes place in these individuals.

That the operation in competent hands is not associated with great danger is indicated by the fact that one postoperative death has occurred in 250 patients with essential hypertension. This patient died from a coronary thrombosis on the second day following the second stage operation. Superficial wound infections were encountered in 4 cases which were readily controlled by immediate drainage and removal of the black silk sutures. In none of these cases of infection has the thoracic cavity been involved. In several cases slight pleural effusion has developed and in only 3 instances was aspiration thought necessary; in the remaining cases the effusion subsided within a few days without aspiration. Unfortunately, severe postoperative discomfort which was directly due to mechanical intercostal neuralgia occurred in a considerable number of these patients and lasted from several days to several weeks.

SUMMARY

A technic for extensive thoracolumbar sympathectomy is described which allows adequate exposure for removal of the sympathetic system from the fourth thoracic to the third lumbar ganglia, inclusive.

After the fourth thoracic ganglion has been mobilized, the trunk is divided above it. The entire mobilized upper sympathetic trunk and its branches are then pulled down through the aperture made by the removal of the eleventh rib, care being taken that the entire system is kept in continuity so that there can be no question or possibility of leaving any ganglia, or any fibers that lead to the thoracic aorta. Care must be taken that the thoracic ganglia are separated from the intercostal nerve and artery before dividing the rami to avoid unnecessary



Fig. 438. The more common appearance of the thoracic and lumbar ganglia with their splanchnic branches, also the aorticorenal from the first and second lumbar.

bleeding (Fig. 433, inset). All bleeding, even from a larger intercostal artery, can readily be controlled by the electrosurgical unit.

It has been my experience that the dissection is less difficult if the thoracic trunk is not divided until the desired number of ganglia that are to be removed have been mobilized.

After the thoracic ganglia and trunk, as well as the splanchnic nerve, have been completely mobilized in continuity to the diaphragm, the iliocostalis and longissimus dorsi muscles which are called the sacrospinalis muscle at the level of the twelfth rib, are retracted medially toward the spine. This permits the lumbodorsal fascia as well as the transversalis fascia to be incised, care being taken during the dissection that the iliohypogastric nerve is not injured. The retroperitoneal space is then entered and the soft tissues retracted anteriorly. The greater splanchnic nerve can be readily identified as it emerges through the diaphragm, usually through a hiatus of its own (Fig. 433), although it may

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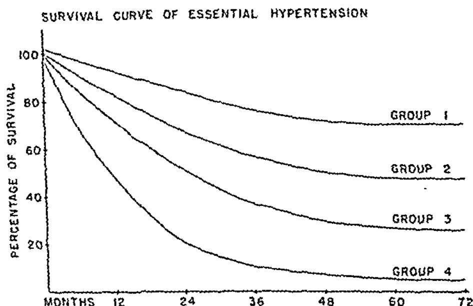


Fig. 439. Survival curve of essential hypertension. (Keith, Wagener and Barker.)

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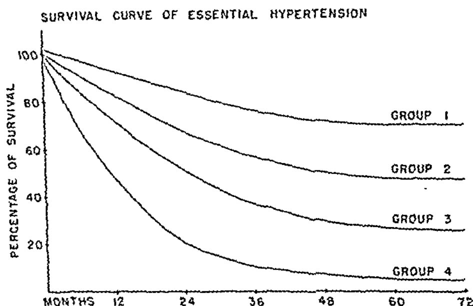


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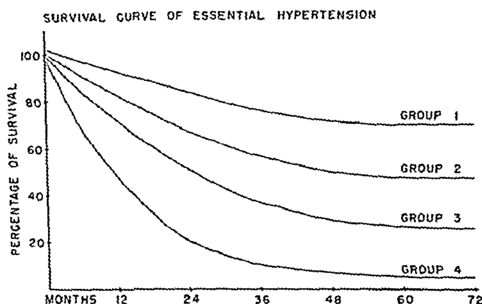


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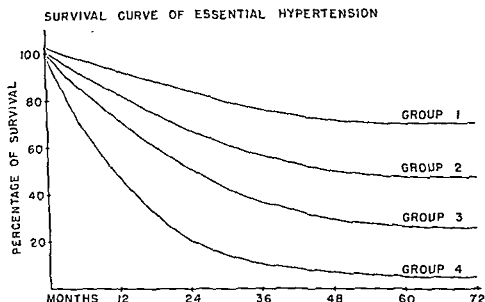


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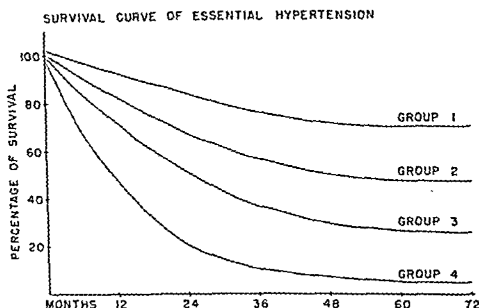


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Fig. 440. *Left,* Normal sympathetic ganglion and fibers. *Right,* Amputation neuroma at site of celiac ganglion resected four years previously.

raised from the twelfth thoracic to the third or fourth thoracic ganglion (Fig. 433, page 797, Fig. 434, p. 798, and Fig. 437, p. 799). Poppen, who performed these operations, reported his results during this gradual rise in 1947.[2] Good and fair results in Grade III patients rose from 37 per cent to 63 per cent in a group whose operations ranged in extent from the eleventh thoracic to the fourth thoracic ganglion.

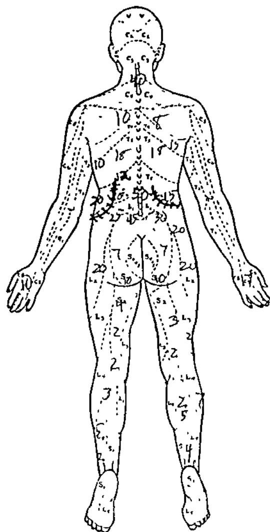


Fig. 441. Sweat test. This patient had a resection to the twelfth thoracic ganglion only, seven years before reoperation and the splanchnics cut at the celiac ganglion. The low figures show the minute current transmitted by the dry resistant skin in the legs which remain sympathectomized, yet the splanchnics were found regenerated at operation.

Experience with 3 patients with recurrent hypertension who had a second operation has supported us in our decision to raise the level of sympathetic resection. Branches to the splanchnic nerves always arise from the seventh thoracic and sometimes from as high as the third thoracic ganglions. Although the greater and lesser splanchnic nerves were cut at the level of the diaphragm in the seventh or twelfth thoracic to the third lumbar type of operation, these branches were found to have grown down again, reforming an amputation neuroma at the site of the celiac ganglion in all three cases (Fig. 440). In 1 case the growth was found to surround a silver clip left at the previous operation. The first operation

had been at the level of the twelfth, eighth and seventh thoracic ganglions, seven, five and four years before, respectively. Sweat tests (Fig. 441) showed the sympathetics to the leg had not regenerated. Reoperation resulted in further drop in blood pressure in two patients. This led us to conclude that the splanchnic nerves constitute the most important area to be resected for decrease in blood pressure. A recent report from Smithwick's[3] group supports this contention.

It is difficult to test for splanchnic regeneration. Theoretically, there should be absence of abdominal visceral pain following splanchnicectomy, but only recently 2 patients have exhibited severe abdominal pain within a few days after operation, 1 from gallbladder disease and the other from an irritable spastic colon, without any sign of peritoneal irritation to account for the pain. Studies are being carried out with balloon distention of the gut and in 1 patient in whom this test was made no pain was experienced, yet at reoperation regeneration of the splanchnic nerves was found. Such regrowth of the thoracic sources of the splanchnics down into the celiac area, however, is only suggestive evidence of the necessity of resecting the splanchnics to their point of transit through the thoracic ganglions. We have no histologic or physiologic proof as yet that these new preganglionic fibers have actually established synapses in the celiac ganglion and are again functioning.

It must be stated *a priori* from our point of view as internists that we cannot accept six-month to three-year follow-ups in a chronic disease such as hypertension with any notion of forming reliable conclusions. To promise a patient of 30 with hypertension that he will live to the age of 70, an expanse of forty years, is as yet absurd. We are not even in a position to predict that patients with Grade III hypertension will exceed the 20 per cent expectation of surviving four years. All we can hope is that the observed reversal of retinal arterial changes toward normal, the frequent reduction in heart size and the improvement of kidney function should prolong life. We must wait twenty years for data in Group II cases, and ten years in Group III cases to demonstrate that this procedure will check cardiovascular renal degenerative disease. In this regard Palmer[4] has stated there is a law of diminishing returns the longer the follow-up, from two-thirds good results at the end of one year to 25 per cent at the end of three years, including all grades of hypertension. He also stated that a comparative group of 100 patients treated medically over three years had only half the number of good results.

High dorsolumbar sympathectomy has led us to reverse our criteria for the selection of patients Formerly, we only thought, "Is this case mild enough with little enough cardiovascular degeneration to promise a good result?" The former operation was a comparatively less formidable procedure, possible, as Peet does it, in one stage, and required a comparatively short convalescent period of one to three months. Our present operative procedure has not resulted in raising the operative mortality rate. Three and a half to five weeks' hospitalization for a two-stage operation is necessary. Full economic recovery has required an average of five and a half months' convalescence for those patients now back at work. Nineteen patients were not back at work after one year. Much pain may be experienced for two to four months

The main effect on the blood pressure is a profound orthostatic hypotension. In

the first six months we have often substituted only one disease for another, namely, orthostatic hypotension for hypertension. This hypotension routinely requires a special corset with a spring suprapubic pad and elastic leg support (Fig. 442). In 19 cases we have had to resort to special pneumatic leggings patterned after the G-suit* of our aviators (Fig. 443). This device has enabled such patients



Fig. 442.



Fig. 443.

Fig 442. Girdle with suprapubic spring pad worn for orthostatic hypotension after high dorsolumbar sympathectomy (Spencer Corset Company).

Fig 443. Pneumatic leggings worn for severe hypotension following high dorsolumbar sympathectomy (Spencer Corset Company).

to return immediately to at least part time work and has been worn for periods of from one to three months, when they are able to discard it.

A profound drop of blood pressure after the second stage may lead to problems of reduced cerebral and coronary circulation in patients who have already had a cerebral or coronary thrombosis and requires extra efforts to maintain a higher blood pressure the first two days after operation. Our main reliance is on a con-

* The corset and G-suit are supplied by the Spencer Corset Company, to whom we are also indebted for the photographs.

stant flow of 1 per cent solution of neosynephrin in 5 per cent glucose and maintenance of shock position.* Another rare undesirable effect of this type of operation has been the appearance of Raynaud's phenomenon in the fingers of three patients. Palmer[4] has also reported such occurrences.

The prolonged and often extremely uncomfortable convalescence now makes us ask, "Is this patient's hypertension producing, or is it likely soon to produce, enough cardiovascular renal degeneration to justify such a serious operation? In the second place, are the changes already present irreversible?"

CRITERIA FOR HIGH DORSOLUMBAR SYMPATHECTOMY

Our criteria for selection of patients, since adopting the almost complete sympathectomy has, therefore, drastically changed in the past three years, and the purpose of this review is to determine whether results have justified operating on patients with more advanced hypertensive vascular disease. Two courses were open to us: to operate on all patients with hypertension except the almost moribund, or to put a ceiling on our indications. Former experience during our period of gradually raising the level of sympathectomy and the reports of others in the field–Smithwick,[5] de Takats,[6] operating to levels as high as the ninth thoracic ganglion and Grimson[7] with a complete sympathectomy–made us choose the latter course. This policy has led us to set up a negative set of standards or certain criteria which if present would contraindicate operative procedures.

Parenthetically, the Wagener-Keith classification[8] of hypertension which we have used in previous reports from this clinic and are using again for the sake of comparison, may be reviewed.

Group I. Patients whose blood pressure drops to normal on rest with Grade I fundi, the earmark of which is increased light reflex only.

Group II. Patients whose blood pressure drops to normal or near normal on rest or sedation with sodium amytal. Fundi are Grade II, the earmark of which is compression at the arteriovenous crossings and often some spasm.

Group III. Patients whose blood pressure drops but little on rest or sedation; fundi, earmark of which is hemorrhage or exudate often with marked spasm.

Group IV. Patients with high blood pressure which does not drop on bed rest or sedation with sodium amytal. In the latter test, the diastolic pressure stays well above 100. Fundi are Grade IV, the earmark of which is choked disk or edema of the disk. There is also hemorrhage, exudate and fragmentation of the vessels.

It must be stated here that many patients with Grade III or IV fundi may have labile blood pressures, that is, the diastolic pressure will still drop below 100 mm. of mercury on sedation with sodium amytal or will drop after etamon to below 100 mm. in the supine position (etamon will cause an orthostatic hypotension in almost all patients with any grade of hypertension and by experience such an orthostatic hypotension indicates nothing).

Our cases are tabulated according to Wagener and Keith's classification based on fundi alone for the sake of simplification, and because earlier reports from this

* A note of warning is appended, two efforts to maintain a higher blood pressure level by pneumatic leggings led to temporary ischemic paralysis and foot drop when the systolic blood pressure fell to 80 mm., the level of air pressure found necessary to keep the suit inflated to raise the blood pressure 10 mm.

clinic have also been on this basis. Although Wagener and Keith required certain degrees of lability of blood pressure in order to classify cases in each of their four groups, practically, it is impossible to do so because a patient with Group IV fundi may have Group I lability. A reclassification, therefore, along the lines suggested by de Takats,[6] taking into account lability, vascular and visceral damage, would seem more practical and satisfactory since results from all types of sympathectomy fall in line better with such a regrouping. For instance, a patient with Grade III or occasionally even Grade IV fundi may have a good result if the blood pressure is still labile, and renal, cardiac and vascular damage is still moderate. All 10 of de Takats' patients in Group III died, 9 within one year, whereas many patients with Grade III fundi have good results.

What we have termed our *negative criteria* for operation are as follows:

1. We rarely operate immediately on patients with Grade I fundi and with blood pressures that fall to normal on rest in patients of any age. We prefer to follow their course for a few years and attempt psychotherapy in the neuropsychiatric department, in most of the young patients. We believe that many of these patients have benign hypertension and will tolerate their labile blood pressure well for a normal life span. If under observation their basal resting diastolic pressure is consistently found to be above 100 mm. or signs of vascular or cardiorenal damage develop, we advise operation.

2. We rarely accept patients over 50 years of age but have operated upon a few between 50 and 57 years of age if they still had a labile blood pressure, did not show evidence of arteriosclerosis or did not have Grade IV fundi. By labile blood pressure we mean a diastolic pressure that will fall below 100 mm. of mercury after administration of sodium amytal and below 100 mm. in the supine position after giving 3 cc. of etamon intravenously. Our search for arteriosclerosis includes roentgenograms for calcification of the cerebral arteries as well as evidence of calcification in the aortic arch in the routine seven foot chest plate, of the pelvic arteries in the intravenous pyelogram, and often a roentgenogram with soft technic for the arteries in the leg. The presence of arcus senilis and palpably hardened peripheral arteries is included in the vascular survey.

3. We reject patients with long-standing hypertension who have reached the age of 50 and who seem to be tolerating their hypertension well; in other words, their renal function is still good, their hearts are not enlarged and they have only Grade I or II fundi. These patients probably will live as long without operation as with it.

4. Patients are refused surgery who have marked hemiplegic residual symptoms in whom operation would hardly be worth while because of marked hemiplegic crippling effect. Minor cerebrovascular accidents from which the patient has largely recovered do not by themselves contraindicate operation.

5. No patient is accepted who has severe right side congestive failure, but those who have experienced episodes of nocturnal dyspnea (pure left ventricular failure) are not considered to have a contraindication if renal function is good and the blood pressure labile.

6. We reject patients who have any severe degree of coronary insufficiency or who have had coronary infarction. The existence of mild angina pectoris with normal exercise tolerance tests, a normal sized heart, and without much dyspnea

on exertion, or angina pectoris with a large neurogenic factor does not contraindicate operation. Indeed, a patient with such findings is now subjected to a sympathectomy to the stellate ganglion level to include the anginal pathway.

7. We do not accept patients with poor renal function, especially if the nonprotein nitrogen remains over 40 mg. per 100 cc. or if the intravenous pyelogram shows inadequate concentration of the dye. Poor concentration on the Fishberg test, poor phenolsulfonphthalein excretion, albumin in the urine, poor urea clearance, and a few casts or red blood cells in the urine should not individually rule out a candidate. A combination of such poor tests, however, points to such renal damage that it may be considered irreversible and the patient rejected for operation.

8. We carefully screen out the following: glomerulonephritis, coarctation of the aorta, polycystic kidneys, pheochromocytoma, brain tumors, endocrine disease such as Cushing's syndrome, the systolic hypertension of arteriosclerosis and patients with unilateral Goldblatt's kidney. In the case of Goldblatt's kidney it has been our policy to do a splanchnicectomy on the same side as we do a nephrectomy. We then wait to see whether there is a secondary rise of blood pressure after this first stage splanchnicectomy. If there is, splanchnicectomy on the other side is carried out. If there is not a rise of the blood pressure after the first stage splanchnicectomy, we attribute the hypertension to the Goldblatt's kidney and do not complete the splanchnicectomy.

9. Finally, we reject the patient with Grade IV fundi if he has a fixed blood pressure with or without the usual widespread cerebrocardiorenal disease.

The *positive indications* for operation are:

1. We urge operation on patients with Group II fundi and labile blood pressure, believing that we get good results in 73 per cent. We especially recommend operation if there are signs of degenerative cardiovascular or renal disease which we believe are still reversible. This may include individuals with an enlarged heart but without a history of congestive failure. If there is evidence only of early renal sclerosis with albumin in the urine, some limitation of concentration function and nocturia, they are accepted for operation. Albumin and nocturia will often disappear after splanchnicectomy. In this group, too, we believe that spasm and compression in the fundi constitute a positive indication for operation rather than a contraindication, providing the blood pressure is still labile and there is no advanced arteriosclerosis.

2. We operate on many patients with Group III or IV fundi if there is a fair degree of lability of blood pressure and none of the cardiovascular renal contraindications stated under "negative criteria." We inform the patient and family that if he does not have an operation, the four-year survival rate is 20 per cent. If he is operated on the four-year survival rate may be 50 per cent. Do they want to take a chance with nature or with surgery? If the family understands the situation, operation is performed. Of course, it is in this group that the operation earns ill repute. We cannot deny splanchnicectomy to the 36 per cent of these patients who will have good results plus 41 per cent of patients who will have fair results.

3. We also include patients for operation who have chronic pyelonephritis

with hypertension whose nonprotein nitrogen is not elevated and whose intravenous pyelograms still show fair power of concentration. An added requirement for the treatment of chronic pyelonephritis is to sterilize the patient's urine before operation.

RESULTS

The results tabulated are for a follow-up period of six to thirty-three months, average eleven months. In computing our results we have compared in Table 1 the patient's first "off-the-street" blood pressure reading with an "off-the-street" supine blood pressure reading after operation at the last follow-up visit. To rank the result on supine blood pressure as excellent we have required a normal

Table 1. Results of High Dorsolumbar Sympathectomy on Supine Blood Pressure

	GROUP I	GROUP II	GROUP III	GROUP IV	TOTAL
Excellent	3	31	5	0	39
Good	3	29	9	1	42
Fair	1	19	11	2	33
Poor	1	32	20	6	59
Total	8	111	45	9	173

Summary of Results on Supine Blood Pressure

	GROUPS I AND II	GROUP III	GROUP IV	TOTAL
Excellent or good	55.5%	31.0%	11.0%	46.8%
Fair	16 8%	24 5%	22.2%	19.0%
Poor	27 7%	44.4%	66.6%	34.1%

blood pressure. To rate the result as good, there must have been a fall of 50 mm. systolic and 20 mm. diastolic, and the blood pressure must have fallen below 200 mm systolic and 120 mm. diastolic. To rank the result as fair, the systolic must have dropped 30 mm. and the diastolic 10 mm., but the blood pressure is above 150 mm systolic and 100 mm. diastolic. The blood pressure drops of 10 patients who died several months after operation are included in these tables on supine and standing blood pressure.

We have also compared the "off-the-street" blood pressure of the patient's first visit with the standing blood pressure of the final follow-up visit (Table 2) This comparison, naturally, yields the most impressive results. We have been especially interested in the marked orthostatic hypotension produced by this extensive operation since it is believed to cause a redistribution of circulating blood volume responsible for the relief of symptoms and cardiovascular improvement. If the patients live longer following splanchnicectomy it is probably because such an orthostatic hypotension has been brought about. Furthermore, the high supine blood pressure recorded in the physician's office may not be that of the patient when he is asleep supine. In other words, the average blood pressure the clock around is bound to be much lower in the patients who have obtained a good orthostatic hypotensive result.

In the table for orthostatic effect on blood pressure after sympathectomy,

excellent means a blood pressure after one minute or more in the standing position, not exceeding 150 mm. systolic and 100 mm. diastolic; good means an orthostatic blood pressure above 150 mm. systolic and 100 mm. diastolic, with a marked drop compared with the "off-the-street" blood pressure before operation. For a fair rating there has been only a moderate drop in blood pressure but a standing pressure below 200 mm. systolic and 120 mm. diastolic. A

Table 2. Results of High Dorsolumbar Sympathectomy on Orthostatic Blood Pressure

	GROUP I	GROUP II	GROUP III	GROUP IV	TOTAL
Excellent	6	62	15	2	85
Good	0	14	7	1	22
Fair	2	23	11	2	38
Poor	0	10*	10	4	24
No report		2	2		4
Total	8	111	45	9	173

* 1 operative death.

Summary of Results on Orthostatic Blood Pressure

	GROUPS I AND II	GROUP III	GROUP IV	TOTAL
Excellent or good	69 0%	48.8%	33.3%	62 0%
Fair	21.0%	24.4%	22.2%	22.0%
Poor	8.4%	22.2%	44.4%	13.8%
No report	1 0%	4.4%		2.3%

rank of poor means the standing blood pressure is still above 200 mm. systolic and 120 mm. diastolic, or with no or very little drop (Table 2).

COMMENT ON RESULTS ON SUPINE AND ORTHOSTATIC BLOOD PRESSURE

From a review of Tables 1 and 2 it is apparent how frequently a good orthostatic drop in blood pressure is obtained and how disappointing the effect on the supine blood pressure may remain. Only 34 out of 119 patients with Groups I and II fundi had normal postoperative blood pressure when lying down, but 68, or more than one half, had normal blood pressures when standing up. Only one-ninth of the patients with Group III fundi had normal supine blood pressures following operation, but one-third had a normal blood pressure when erect. About a fourth of patients with Groups I and II fundi had poor results on supine blood pressure, but only 8.4 per cent had a poor result on their erect blood pressure. In Group III, 44 per cent of the patients had poor results on supine blood pressure and 22 per cent when the patient was standing Of the entire series of 169 patients, on whom there is a report on the standing blood pressure, only 24 or 14 per cent failed to obtain at least a moderate drop of their blood pressure when they were erect.

SYMPTOMATIC IMPROVEMENT, ECONOMIC STATUS AND "TOTAL SCORE"

In arranging our statistical tables for symptoms and economic status (Tables 3, 4 and 5) we tried to avoid the old cliché that one can prove anything by statistics and looked at the results from the viewpoint of both the patient and

his referring physician. Our criteria for scoring in Tables 3, 4 and 5 are as follows:

Under symptoms, complete relief counted a score of excellent. Good means relief of all but one of the following symptoms: nervous tension, headache,

Table 3. Relief of Symptoms after High Dorsolumbar Sympathectomy

	GROUP I	GROUP II	GROUP III	GROUP IV	TOTAL
Excellent	0	9	1	0	10
Good	5	69	25	1	100
Fair	3	14	11	2	30
Poor	0	6*	4*	6*	16†
No report		13	4		17
Total	8	111	45	9	173

* 4 deaths.
† 12 deaths

Summary of Results on Symptoms

	GROUPS I AND II	GROUP III	GROUP IV	TOTAL
Excellent or good	69 7%*	57.7%*	11.1%	63.5%
Fair	14.3%	24.4%	22.2%	17.3%
Poor	5.0%†	8.9%†	66.6%†*	9.2%‡
No report	11.0%	8.9%		9.9%
Total	100%	99.9%	99.9%	99.9%

* 78% of those patients reporting.
† 4 deaths.
‡ 12 deaths.

Table 4. Economic Status after High Dorsolumbar Sympathectomy

	GROUP I	GROUP II	GROUP III	GROUP IV	TOTAL
Excellent 100% at 3 mos.)	1	17	2	0	20
Good (100% at 6 mos.)	1	40	14	1	56
Fair (75% at 6 mos.; 100% at 1 yr.)	2	16	5	2	25
Poor (not working)	1	4*	8*	6*	19†
No report	3	34	16		53
Total	8	111	45	9	173

* 4 deaths.
† 12 deaths

Summary of Economic Status

	GROUPS I AND II	GROUP III	GROUP IV	TOTAL
Excellent or good	49 5%	35.5%	11.1%	44.0%
Fair	15.1%	11 1%	22.2%	14.4%
Poor	4.2%	17 7%	66 6%	11.0%
No report	31 1%	35 5%		30.6%

dizziness, fatigue, plus a sense of well-being. Fair represents partial relief of all or most symptoms, or partial return of some symptom, usually headache. The 12 deaths in the entire series were counted poor as regards symptoms and economic status. Economic improvement is explained in the table.

The total score (Table 5) was computed as follows: excellent in any of the categories counts four points toward a total of 16, good counts 3; fair counts 2; poor 1; no report 0. The count of 1 for poor was compensated for by raising the total requirements 1 point for each final category in the "total score."

A score of excellent in the "total score" requires 15 to 16 points; good 10 to 14 points; fair 7 to 9 points; any score below 7 rates poor. The 12 fatalities are rated poor. Thus one patient in Group III who had a good result in all four categories for a total score of 12, died from a sudden cerebral accident nine months after operation, but must naturally be counted a poor result.

Table 5. Total Score

	GROUP I	GROUP II	GROUP III	GROUP IV	TOTAL
Excellent	0	4	0	0	4
Good	7	77	20	1	105
Fair	1	19	19	3	42
Poor	0	8	6	5	19
Insufficient data		3			3
Total	8	111	45	9	173

Summary of Total Score

	GROUPS I AND II	GROUP III	GROUP IV	TOTAL
Excellent or good	74.0%	44.4%	11.1%	63.0%
Fair	16.8%	42.2%	33.3%	24 2%
Poor	6.7%	13.3%	55.5%	11.0%
Insufficient data	2.5%			1.7%

COMMENT ON SYMPTOMATIC IMPROVEMENT, ECONOMIC STATUS AND "TOTAL SCORE"

Seventy-eight per cent of patients in Groups I and II and 63 per cent in Group III who reported symptoms on follow-up examination obtained marked relief, but in Group IV two-thirds of the patients failed to obtain relief or died (Table 3).

Seventy-two per cent of patients reporting in Groups I and II were working full time six months after operation, 94 per cent by one year (Table 4). Fifty-five per cent of patients reporting in Group III were working full time six months after operation, 74 per cent by one year. Eighty-four per cent of those reporting in the entire series were working full time by one year.

The good "total score" in Grades I and II (Table 5) exceeds the good orthostatic blood pressure result by only 5 per cent, 74 per cent and 69 per cent, respectively. Only 29 1 per cent of patients in these two groups failed to obtain a good orthostatic fall of blood pressure. In patients with Group III fundi the good "total score" and good fall of orthostatic blood pressure were again parallel, 44.4 per cent and 48 8 per cent, respectively, and failure to get a good fall was 46.6 per cent. If one adds the percentage for total excellent and good score to the percentage of failure to get a good orthostatic drop in blood pressure, almost exactly 100 per cent of the patients are accounted for in

Groups I, II and III. This substantiates our belief that the chief benefit of this operation is the redistribution of circulating blood volume.

Only 11 per cent of good results (Table 5) in patients with Group IV fundi, and over one half poor results emphasize the importance of this contraindication to operation.

The results for 15 patients with Group II fundi would be raised from good to excellent on their total score if they had been able to resume full time work in three months instead of six. We have kept this strict criterion because it reflects the long convalescent period from this type of operation.

EFFECT OF OPERATION ON VASCULAR AREAS

While decrease in blood pressure is certainly a desirable result, we doubt that it should be considered the only judge of the benefit of splanchnicectomy since even more startling benefits are often observed even when the fall in blood pressure has not always been satisfactory. Therefore, we have prepared tables showing improvement in areas of cardiovascular degeneration. Bridges et al[9] have reported similar improvement in cardiac findings following dorsolumbar sympathectomy.

Table 6. Cerebrovascular Accidents

	PREOPERATIVELY	POSTOPERATIVELY
Group I	1	0
	0 in 7	0
Group II	9	1
	0 in 101	4 (2 fatal at op)
Group III	9	0
	0 in 33	3 (2 fatal)
Group IV	1	0
	0 in 7	1 (fatal)

1. **Cerebral Vascular Area.** We believe with de Takats[6] and Smithwick[3] that the symptomatic and visceral improvement is due to redistribution of circulating blood with lowering of venous pressure and diminished diastolic cardiac filling, the effect of orthostatic hypotension. Previous experience before this series now reported, had taught us that if cardiac reserve has been too limited before operation, diminished diastolic filling may only tax the heart further and give rise to serious symptoms of forward failure. Reduced coronary irrigation may result in angina of serious coronary insufficiency. On the other hand, we have not observed any ill effects from reduced cerebral irrigation except immediately after operation, after both the first and second stages (Table 6). There were 2 deaths in this series soon after operation from this cause, both in patients who had had no previous cerebrovascular accident.

Twenty patients had had cerebrovascular accidents prior to surgery, only 1 of whom had a subsequent nonfatal stroke. Of patients who never had had similar troubles, there were 8 cerebrovascular accidents, varying in time from a few

days to several months after operation, 2 of which were fatal. It would seem a previous cerebrovascular accident need not deter us from operating.

2. **Cardiac Vascular Area.** A. *Angina* (Table 7). Nine of 15 patients with angina experienced abolition of pain and 2 partial relief. Angina remained the same in 1, became worse in 2, one of these patients dying of coronary infarction. Since one-third of our patients with angina did not obtain complete relief, we feel supported in our present practice of resecting bilaterally the

Table 7. Angina

GROUP I				GROUP II				GROUP III				GROUP IV			
Before	After	Left	Right	Before	After	Left	Right	Before	After	Left	Right	Before	After	Left	Right
+	0	T-4	T-5	+	0	T-4	T-5	+	0	T-4	T-4	+	0	T-4	T-4
				+	++*	T-4	T-5*	++	+	T-4	T-4				
				0	+	T-4	T-4	+	+	T-4	T-4				
				+	0	T-4	T-4								
				++	0	T-5	T-4†								
				+	0	T-3	T-5								
				+	0	T-4	T-4								
				++	+	T-4	T-4								
				0	+	T-3	T-5								
				+	0	T-2	Stellate								

* Died of coronary infarction 12 months after operation.
† Died of auricular fibrillation 16 months after operation.

anginal pathway of the first, second, third and fourth thoracic ganglions. We did not operate on any patient with an electrocardiographic pattern of coronary infarct.

In the last series of cases reported from the Lahey Clinic by Poppen[2] there were 8 patients with angina, in none of whom was resection carried to the fourth thoracic level. Only 1 patient obtained complete relief, 2 patients were better as

Table 8. Change in Heart Size

	CASES	
Enlarged before operation		51
Normal size 3 to 6 mos. after operation	20	
Reduced but still enlarged	8	
No change	2	
Larger	1	
Unreported	20	

Reduction of size in 90%, 64% to normal

regards angina, and 5 subsequently died. When operation was below the fourth thoracic level, there was 12.5 per cent relief; at the fourth thoracic level, 60.0 per cent relief, 1 patient undergoing resection to the second thoracic ganglion on the left and to the stellate ganglion on the right. It will be interesting to note what the results on angina will be when more patients are subjected to the still higher operation.

B. *Heart Size* (Table 8, Fig. 444). The hearts of 51 patients were reported preoperatively to have a transverse cardiac diameter greater than 50 per cent of the greatest transverse diameter of the chest. Twenty of these revealed normal ratios, many as soon as three to six months after operation; in 8 the heart was reduced in size, 2 showed no change and in 1 the heart was larger. There

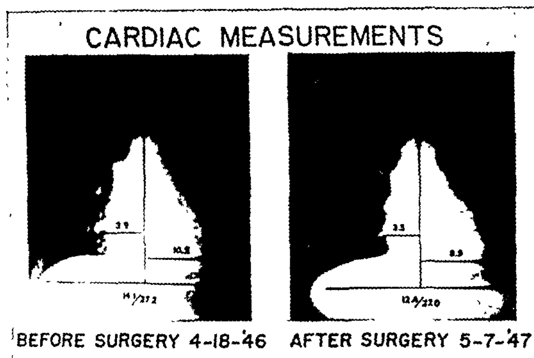


Fig. 444. Decrease in heart size to normal one year after sympathectomy.

was no follow-up on heart size in 20 per cent. Of those with check-up examinations after operation, 90 per cent showed reduction in the transverse diameter of the heart, 64 per cent to normal.

C. *Electrocardiogram* (Table 9, Fig. 445). Of a total of 173 patients the electrocardiograms were normal in 41 and abnormal in 92 before operation.

Table 9. Electrocardiographic Data

	Left Axis Deviation Only					Left Ventricular Strain				Normal		
	Total	Improved	Same	Worse	No Report	Total	Improved	Same	No Report	Total	Same	No Report
Group I	1				1					6	1	5
Group II	27	2	8		17	28	11	7	12	30	6	24
Group III	16	0	11	1	3	19	8	2	9	3		3
Group IV						1			1	2	2	

Fifty of these latter patients had follow-up electrocardiograms after operation. Of these 50, 21 showed improvement (42 per cent), 28 no change and 1 was worse.

D. *Aorta.* Of 11 patients who had widened, tortuous or calcified aortas, 5 had a total score of good, 3 of fair and 3 poor, making 8 patients in whom the operation may have been worth while. In a few of these patients the aorta was noted to be less tortuous after operation.

3. **Renal Area** (Table 10). A. Nocturia was a symptom in 45 of the entire series of 173 patients. There was complete or partial relief in 34, or 75 per cent. Nocturia remained the same in 9 and became worse in 2.

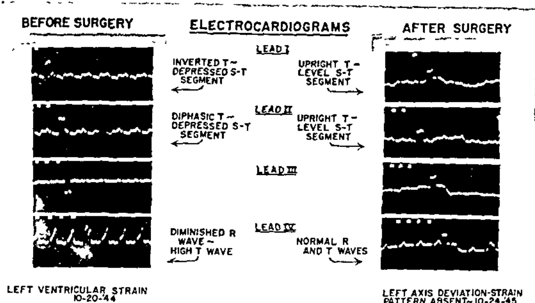


Fig 445. Disappearance of left ventricular strain pattern one year after sympathectomy.

B. Impaired renal functional tests were found in 55. After operation there was improvement in one or more tests in 32, or 58 per cent. The tests were practically the same in 18 and worse in 5. The tests included in this summary were for albumin, casts, Fishberg concentration tests, and often a phenolsulfonphthalein excretion and urea clearance test.

Table 10. Renal Function

	NOCTURIA	IMPROVEMENT	SAME	WORSE
Group II	21	14	6	1
Group III	21	17	3	1
Group IV	3	3		

	IMPAIRED	IMPROVED IN 1 OR MORE TESTS	SAME	WORSE
Group II (adequate comparative tests before and after operation)	36	21	12	3
Group III (adequate comparative tests before and after operation)	16	8	6	2
Group IV	3	3		

4. **Fundi** (Table 11). A follow-up examination of the fundi was recorded in 117 patients in Grades II, III and IV. All fundi were graded by the senior author (J. A. E.). There was a reversion to normal in 12, in 1 of whom the fundi were originally Grade III. Thirty-seven of 73 who had Grade II fundi improved to Grade I, 25 showed no change, 38 with Grade III fundi were checked

and 29 changed to II, 6 to I and there was no change in 2. Of 6 patients with Grade IV fundi, 1 changed to III, 3 to II and 2 to I. It is to be noted that all Grade IV fundi improved. Two patients who were practically blind were able to read again one to two months following operation. No ocular fundi became worse after operation, although with the passage of time some Grade III fundi

Table 11. Fundi

	GROUP II	GROUP III	GROUP IV
Reverted to I	37	6	2
Reverted to II		29	3
Reverted to III			1
Reverted to normal	11	1	
No change	25	2	
Advanced	0	0	0
Total	73	38	6

which improved for a while reverted to Grade III. These are included under no change.

ANALYSIS OF DEATHS

There were 12 deaths in the entire series of 173 patients, a mortality of 7 per cent within a six to thirty-three month follow-up period. Two fatalities occurred before the patient had left the hospital, giving an operative mortality of 0.5 per cent (2 operations were carried out on each patient). Both these figures are the same as in Poppen's last series of lower resections. Ten patients

Table 12. Analysis of Deaths

	TOTAL DEATHS	OPERATIVE MORTALITY	CASE MORTALITY			
		Cerebrovascular Accident	Coronary	Cerebrovascular Accident	Uremia	Cause Unknown
Group I	0	0				
Group II	4	1	2 {18 mos., 15 mos.}			13 mos.
Group III	4	0		2 {11 mos., 10 mos.}	7 mos.	12 mos.
Group IV	4	1		14 mos.	2 {7 mos., 5 mos.}	
Total	12					

Operative mortality, 0.5%.
Mortality, 7%.

died five to eighteen months after operation, 2 of these 10 from coronary occlusion, 3 of cerebrovascular accident, and 3 of uremia. The cause of death is unknown in 2 (Table 12)

There was improvement in 42 per cent of 50 patients who had abnormal electrocardiograms.

Seventy-five per cent of 45 patients with nocturia reported complete or partial relief. At least one renal function test was improved in 58 per cent of 55 patients who had one or more impaired tests before operation.

Retinal vascular change improved in 66 per cent of 117 patients on whom follow-up examination was possible.

Operative mortality was 0.5 per cent; mortality rate for the entire series within the follow-up period of six to thirty-three months was 7 per cent.

We are loath to consider this type of operation with its prolonged uncomfortable convalescence as a prophylactic operation for benign hypertension but urge it on patients under 50 years of age with spastic, exudative and hemorrhagic retinal arteriolar changes, moderate cardiac damage, signs of early nephrosclerosis and labile blood pressure.

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THE TECHNIC OF LUMBAR SYMPATHECTOMY

JAMES L. POPPEN

Surgery of the sympathetic nervous system has been gathering momentum over the past few years, with varying results. As is true of many relatively recent types of surgery, lumbar sympathectomies have been carried out unnecessarily in some instances. In doing so, however, reasonably clear cut indications and contraindications have evolved. That the operation is of great merit in well selected cases cannot be overemphasized. Many lower extremities have been saved by timely lumbar sympathectomy.

The indications for lumbar sympathectomy are mainly peripheral vascular diseases such as thrombo-angiitis obliterans (Buerger's disease), Raynaud's disease, arterial embolism, arteriosclerosis, livedo reticularis, chronic ulcers, causalgia, hyperhidrosis and traumatic sympathetic reflex dystrophy. The decision as to whether sympathectomy should be carried out in a given individual can usually be determined by adequate preoperative studies, especially by a temporary interruption of the lumbar sympathetic pathways with a well directed procaine block. By this means a reasonably accurate knowledge can be obtained as to the efficacy of lumbar sympathectomy. Unfortunately, temporary procaine block cannot be relied on completely. This is especially true in the advanced cases of Buerger's disease and arteriosclerosis. In many of these patients there may be an element of associated arterial spasticity which is not determined by temporary procaine block. In Buerger's disease and arteriosclerosis more information may be gained by subjecting the extremities to cold atmosphere; if the temperature in the extremity does not fall within a reasonable length of time, sympathectomy, in all probability, will not be of help. In several instances the lumbar sympathetic block will not result in a rise in the skin temperature of the extremity, however, by permanent interruption of lumbar sympathetic pathways, a rise in temperature can readily be measured as well as an increase in circulation demonstrated by pulsation in a peripheral vessel which was pulseless before operation. If pain in the lower extremity, caused by peripheral vascular disease, is not relieved by a procaine block, one can be reasonably certain that relief will not be obtained by sympathectomy. It is equally true that relief of ischemic pain is not always obtained by operation even though a satisfactory relief seemed assured by temporary procaine sympathetic block.

I believe that sympathectomy in erythromelalgia should be discouraged in all cases. Certainly in my experience patients have complained more bitterly of burning discomfort after operation than before the sympathectomy.

Since lumbar sympathectomy can now be performed in a few minutes, necessitating only a short hospital stay, it is justifiable to institute the procedure in certain patients with advanced arterial disease in whom the results of preopera-

Originally published in Surgical Clinics of North America, 29 667–671 (June) 1949.

tive tests have been questionable. It is important in all patients with advanced disease to perform an adequate sympathectomy. In all patients who have Buerger's disease or arteriosclerosis in whom the operation is performed, the first, second and third lumbar ganglions should be removed, preferably including the twelfth thoracic. It is equally important to perform a minimal sympathectomy in cases of hyperhidrosis in which the upper as well as the lower extremities are involved. The disagreeable excessive perspiration that results in patients who

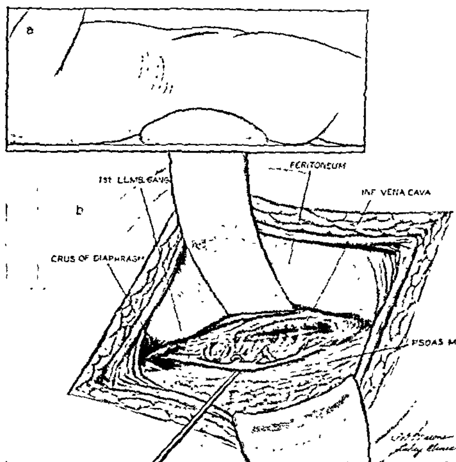


Fig. 446. *a*, Position of the patient and the approximate site of the incision. *b*, Retraction of the soft tissues medially and anteriorly; also the crus of the diaphragm incised.

have had an upper thoracic and a lumbar sympathectomy may be avoided to a great degree by removing only the fourth lumbar ganglion on each side.

Spinal anesthesia is the anesthesia of choice for lumbar sympathectomy. The position of the patient is especially important. I prefer to have the patient in a slightly oblique position, as indicated in Figure 446, *a*. A small skin incision, 3 to 4 inches long, is made corresponding approximately to the course of the muscle fibers of the external oblique, the incision extending from the tip of the tenth rib. The fibers of the external oblique muscles are separated and kept retracted with a small sella retractor. The internal oblique muscle fibers are then separated, as well as the transversalis. Care must be taken in splitting the transversalis muscle that the peritoneum is left intact. The peritoneum is usually retracted by inserting the index and middle fingers through the muscle splitting incision and exerting pressure with the palmar surfaces of those fingers against

the parietal surface of the transversalis muscle laterally. The line of cleavage can readily be followed, sliding gently over the inner surface of the quadratus lumborum muscle to the lateral margin of the psoas major muscle. The fingers are then elevated following the contour of the psoas muscle medially. The palmar

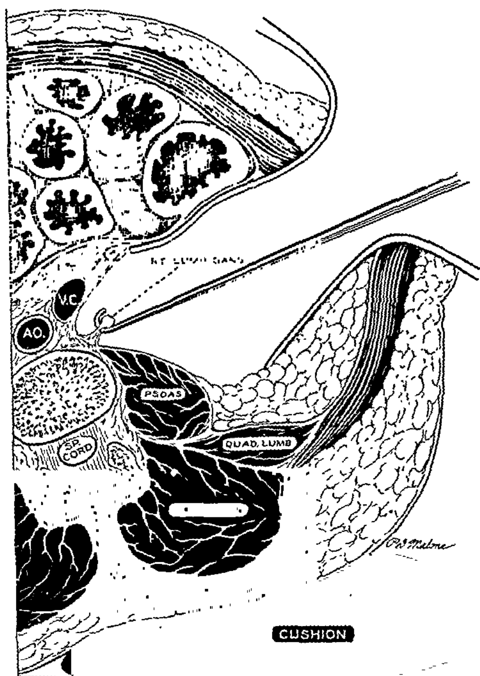


Fig. 447. Relationship of the anatomical structures to the lumbar sympathetic chain through a cephalad transverse section

surfaces of the two fingers lie on the belly of the psoas major muscle, with the peritoneum and its contents displaced medially. Considerable manipulation may be eliminated by inserting a portion of a dental roll attached to a black silk string with a long forceps to the site where the palmar surfaces of the index and middle fingers are firmly kept in contact with the belly of the psoas major muscle. The fingers are removed from the site and the cotton roll kept in con-

tact with the muscle or the forceps. A Grant bladder retractor is inserted, sliding it gently along the forceps to the point where the cotton roll is held on the psoas major. This maneuver allows the peritoneum to be retracted medially so that the psoas muscles can be readily visualized. By gentle retraction medially with the Grant bladder retractor, the line of reflection of the peritoneum will fold on itself, forming a small white line. This is incised, allowing one to enter the proper line of cleavage. The soft tissues are retracted medially to the lateral portion of the bodies of the lumbar vertebrae (Fig. 446, *b*). The lumbar sympathetic chain and ganglions can be readily seen lying in the gutter that is formed by the rounded portion of the bodies of the vertebrae and the psoas minor muscle. The line of cleavage is followed cephalad well above the crus of the diaphragm. The latter is split sagitally, allowing the twelfth thoracic ganglion to be removed if found indicated.

The removal of the sympathetic trunk and the dissection will be greatly facilitated if the rami are divided before either end of the lumbar chain is divided. The sympathetic chain rarely lies beneath the lumbar vessels on the left side; on the right side it occurs quite frequently. The vena cava many times lies over the sympathetic trunk on the right side (Fig. 447); however, it can be gently retracted and the only time that I have found it to be a handicap was during a second operation at which time it may be firmly plastered down by adhesions over the sympathetic trunk.

There should be absolutely no question in the surgeon's mind as to whether the structure is sympathetic trunk or not, even though at times on the right side he may find a fairly long trunk with no intervening ganglion. In those instances a fusion of two ganglions above or below is always found. Certainly, one should never confuse a lymphatic node with a sympathetic ganglion. In the first place they are of entirely different color and if the line of cleavage is properly obtained, the lymph nodes will be retracted away from the sympathetic trunk and therefore give no trouble. The genitofemoral nerve must not be confused with the sympathetic trunk.

It is of importance to the patient that local exploration by palpation be performed during every sympathectomy. The lower pole of the kidney can always be felt. At times a hypernephroma or other condition may be noted. Either the descending or ascending colon can readily be palpated for masses.

The incision is closed with a few black silk sutures. The patient may be allowed up the following day.

The complications of the procedure are minimal. It is of great importance, however, that the patient be informed, if he is a male, that there may be a change in the sexual function. The execution of intercourse will be completely normal except that there will be a dry ejaculation in about 50 per cent of patients In those patients, of course, sterility is inevitable. However, it in no way interferes with the act of intercourse. We have found no sexual change in the female.

ANESTHESIA

PREOPERATIVE PREPARATION AND PREMEDICATION

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In modern medical practice the preoperative preparation of surgical patients is generally a joint undertaking in which the surgeon, internist and anesthesiologist divide the responsibility. When the patient presents an unusual problem, it is not at all uncommon to have the urologist, cardiologist, roentgenologist, pathologist, hematologist and biochemist share in this responsibility. Although the following discussion will deal with the role of the anesthesiologist in this problem, at no time can we afford to lose sight of the fact that he is but one member of a team whose ultimate goal is to prepare each patient so adequately that operative morbidity and mortality will be reduced to a minimum.[3]

Because of the very nature of his specialty, the anesthesiologist must spend most of his time in the operating room and therefore must, of necessity, assume the role of a consultant in the preoperative preparation of surgical patients. However, he should expect to be called in consultation during the preoperative period on such problems as oxygen and fluid therapy, blood transfusions, suction bronchoscopy and diagnostic and therapeutic nerve blocks.

As his visit is generally made after most of the pertinent information has been obtained, the anesthesiologist has a rather unique opportunity to evaluate the patient's physical state. To make the most of this opportunity, the anesthesiologist must know normal physiology and keep abreast of the ever-expanding, newer developments in medicine.

The role of the anesthesiologist in the preoperative preparation of surgical patients will be divided into three parts: (1) the preanesthetic interview, (2) an estimation of the patient's physical state, and (3) preanesthetic medication.

PREANESTHETIC INTERVIEW

Psychologic Management. More time and thought should be given to this important aspect of the practice of anesthesiology. The surgeon generally evaluates the anesthesiologist on the skill and judgment he exercises while administering anesthetics. The surgical patient, however, has only the psychologic approach used by the anesthetist upon which to form his opinion.

The anesthesiologist should never lose sight of the fact that the contemplated operation and anesthesia probably mark a new and unpleasant experience in the life of the patient. More than likely, he is nervous, tense and apprehensive and therefore greatly in need of sympathetic understanding. If the anesthetist could but just imagine he were about to anesthetize a member of his own family, modern anesthesiology would be tempered with more kindness, consideration, tolerance and understanding.

Every surgical patient should be visited preoperatively by the anesthesiologist.

Originally published in Surgical Clinics of North America, 30 635–647 (June) 1950.

Many patients will say that they have no real fear of the operation, but they do have a fear of the anesthesia. This preanesthetic visit allows for the allaying of such fear, gaining the patient's confidence, answering questions, and makes it possible for the anesthesiologist to analyze the entire problem and select the premedication as well as the anesthetic agent and method.

In discussing the proposed anesthetic with the patient one should be careful of his choice of words. To say the gas will not smell badly or the needle will not hurt much is but to raise a question of how badly does the gas smell or how much will the needle hurt. It is better to say the gas will be pleasant to inhale and that it causes one to drift off into a natural sleep or that the needle puncture will feel like a hypodermic injection.

It has always seemed wise to tell the patient beforehand of the proposed operation unless he happens to be psychotic. This has been satisfactory even for those suffering from hyperthyroidism. They are usually happy to know that they are now ready for the operation and that it will soon be over. It is also helpful to tell the patient beforehand that the use of oxygen tents, blood transfusions and so forth are all integral parts of modern postoperative care.

The above-mentioned niceties should be carried out the night before operation. When this psychologic preparation is combined with adequate preanesthetic medication the patient generally comes to the operating room without fear. This accomplishment may be undone if the operating room is run like a postoffice and each patient handled as if he were a package rather than a human being. The operating room is certainly one place where attention should be personalized. Almost any patient will be more eager and willing to cooperate if he is addressed by name and warned of proposed movements of the wheel stretcher or operating table. It is a natural protective reaction on the part of the patient to resist when attempts to pull or shove him about are made without the proper preliminary explanations. It is generally advisable to cover the eyes and put cotton in the ears of patients undergoing operations under spinal anesthesia. However, this may disturb some and cannot be adhered to as a routine measure. Most patients appreciate the constant attention and quiet encouragement of the anesthetist while they are in the operating room and when deprived of it, generally find the experience unpleasant.

Bedside Visit. Much valuable information may be gained from a visit to the patient's bedside. This affords the anesthesiologist an opportunity to become acquainted with his patient, learn something of his personality, carry out a careful inspection and elicit a short history concerning the present illness.

A systematic inspection tells at a glance something of the patient's physiologic age, weight, condition and color of the skin, rate and character of respiration, degree of oxygenation, mental attitude and nutritional state.

Questions may be asked to determine whether there has been recent change in weight, strength, appetite or bowel function. The functional state of the heart may be ascertained by asking questions about dyspnea, orthopnea, palpitation, angina, ankle edema, and the patient's ability to do physical exercise.

As the present illness is usually the reason for the patient's hospitalization, specific questions are asked to obtain information concerning its duration, severity, and so forth.

This approach allows the anesthetist to gain a good idea of the patient's vigor —if he is robust, alert, keen and vigorous he may be considered a good surgical risk, but if he is pale, weak, apathetic and mentally sluggish, the anesthetic risk may well be increased.

From information gained thus far the anesthesiologist may decide that a part or all of the physical examination should be repeated. This is particularly true when evidence of cardiorespiratory imbalance has been discovered.

The patient who enters the hospital with a normal temperature, pulse and respiratory rate but says he "feels like he is coming down with a cold" offers a difficult problem for the anesthesiologist to settle satisfactorily. Should this patient's operation be canceled or should he be considered to be in satisfactory condition for his operation in view of the lack of positive findings? It has been our policy when confronted with a lack of physical findings such as nasal congestion, coryza, pharyngitis, tonsillitis or evidence of tracheobronchitis to ask the patient if he feels as he ordinarily does when he is "catching a cold." If his answer is "yes," then the operation should be canceled. However, it is unwise to make rules regarding the canceling of operations because of an elevated temperature, pulse or respiratory rate. Each case must be settled on its individual merits as such findings may well come from a pelvic abscess, empyema of the gall bladder, acute appendicitis, cellulitis and so forth, and as the therapy of many of these conditions is surgical, all of the evidence must be weighed before recommending that the operation be postponed.

History of a Previous Anesthesia or Operation. If the patient has been anesthetized before, the anesthesiologist should learn all he can about that experience. The premedication may have been unsatisfactory because it was administered too late or the barbiturate may have caused excitement, or the morphine may have precipitated a gallbladder attack. It is not at all uncommon for doctors and nurses or members of their families to report sensitivity to morphine—saying it caused them to vomit, in such instances, dilaudid, demerol or even pantopon may be satisfactorily substituted. Sensitivity to procaine is frequently reported as the result of a peculiar sensation experienced at the dentist's when a procaine-epinephrine mixture was injected into the gums. Almost invariably, these are not manifestations of procaine sensitivity but are reactions caused by the high concentration of epinephrine (1 to 50,000 dilution) customarily used in dental work.

The history of ether having caused prolonged postoperative nausea and vomiting is frequently heard and is extremely difficult to evaluate. However, when this history is obtained, ether is avoided if possible. When "ether pneumonia" (atelectasis) is said to have followed a previous operation, the anesthesiologist must be sure the underlying cause was not a long-standing chronic bronchitis or bronchiectasis. Careful tracheobronchial aspiration of excess secretions immediately after operation, along with good bedside nursing and the institution of deep breathing generally is effective in preventing the recurrence of such a complication

Unfortunately, many complaints are heard about various types of regional anesthesia. The anesthesia was unsatisfactory because the patient was awake, or he heard people talking in the operating room, experienced pain, or the opera-

tion outlasted the anesthesia. It is not uncommon for patients to tell of experiencing pain at the spinal puncture site or having had a paresthesia that extended down the leg when the needle entered the subarachnoid space. These, we consider to be technical difficulties that can be avoided by more careful attention to detail, and they do not contraindicate the further use of spinal anesthesia. However, when a patient gives a history of prolonged motor paralysis, urinary retention, postspinal headache, or paresthesias that extended down one or both legs for days or weeks following operation, it is wise to avoid the subsequent use of spinal anesthesia.

Discussion of the Proposed Anesthetic and Operation. During the course of the interview, the patient is told in a general way about the operation and the proposed anesthetic. Patients seem to enjoy learning the exact time the operation is planned and who the surgeon will be, if they do not already know the latter. They are told that they will be given premedication in the form of a pill and a hypodermic injection which will produce amnesia before they leave the room. Mention is made of the type of anesthesia they may expect to receive, such as gas, intravenous or spinal. At this point the patient may voice an objection to a particular form of anesthesia or express the desire to be asleep if spinal anesthesia is to be employed. No patient should be denied the latter request and when advised that such is the case, the main objection to spinal anesthesia is usually dissipated. It is not uncommon during these discussions for the patient to volunteer that he has claustrophobia and cannot stand a mask on his face; this gives the anesthesiologist the opportunity of promising a pentothal or avertin induction. If during the discussion the anesthesiologist is warned by the patient of a previous delirium or struggle during the excitement stage, it is wise to forestall a repetition of this by giving a short-acting intravenous barbiturate, such as pentothal, for induction. As a matter of fact, this type of induction has proved so satisfactory that its routine use is gaining popularity with patients and surgeons as well as anesthesiologists.

Whenever possible, children are prepared for what will actually happen in the operating room, and this seems to be a more satisfactory way of handling the situation than to say nothing or to deceive them.

Examination of the Patient's Hospital Record. Once the interview at the patient's bedside has been completed, his hospital record should be consulted and the pertinent data obtained and recorded on the anesthesia sheet. To appreciate more fully the complexities of our modern preanesthetic preparation of the surgical patient, one needs but to consider the important role of nurses and highly trained technicians in the collection and examination of laboratory specimens, recording of clinical data and the performance of special studies, such as electrocardiograms, electroencephalograms, basal metabolic rates, roentgenographic examinations, and the grouping and cross-matching of blood for blood transfusions. These varied and important services rendered to each patient have become an accepted part of modern hospital practice and give the average anesthesiologist little concern except when they are omitted or incorrectly performed.

By combining the positive findings obtained through the interview with those already recorded on the patient's chart, the anesthesiologist is able to evaluate

the patient's physical state.[16] This evaluation does not mean an assessment of the surgical risk about to be undertaken, for in this latter consideration such variables as the patient's physical condition, the seriousness of the operation, the skill of the surgeon and the outcome of similar operations in the hands of this particular surgeon all have to be considered. In the final analysis, we are interested in the amount of systemic disease and impaired function the patient shows and it is upon this information that the physical status is decided.

EVALUATION OF THE PATIENT'S PHYSICAL STATE

That a real need exists for better methods of evaluating the physical state of the poor risk surgical patient is keenly appreciated by the surgeon and the anesthesiologist. Too often a patient who is considered to be a good risk for operation shows signs of shock in the operating room, develops a serious complication or succumbs during his convalescence as a result of his underlying, disturbed physiology.

To focus attention on the preoperative treatment of these patients it is essential that a distinction be made between their reversible and irreversible pathologic processes. All too often, much time and worry is spent by the surgeon, internist and anesthesiologist rehashing the irreversible pathologic states that are confronting them. Such conditions as arteriosclerosis, hypertension, valvular and congenital heart disease, pulmonary fibrosis and emphysema, and chronic liver and kidney disease fall into this classification.

While time is being lost discussing the irreversible pathologic processes, reversible ones such as secondary anemia, diminished blood volume, hypoproteinemia, hypoprothrombinemia, dehydration, obesity, diabetes, hypothyroidism and Addison's disease are often neglected. It is on these conditions that emphasis should be placed if we are to give the poor risk patient a real chance of surviving. During the past few years we have seen evidence of the value of improved preoperative preparation in two diseases, hyperthyroidism and bronchiectasis. Little change has been made in the surgical or anesthesiologic management of these diseases, but, nevertheless, the morbidity and mortality rates have gone steadily downward. Even though such specific methods of preparing most of our poor risk patients are still lacking, much progress has been made in the evaluation and treatment of their disturbed physiologic states.

Space will not allow for a detailed discussion of all of this new material; however, brief mention will be made of some of the more important developments. It is believed that the proper application of this newer knowledge in the treatment of the poor risk patient will go far toward the elimination of operative morbidity and mortality. A discussion of some of this material follows.

Circulation. The explanation for the anemic patient's inability to tolerate surgical intervention has been thought to lie in his impaired oxygen-carrying capacity of the blood. The grave danger of allowing cyanosis (5 gm. of reduced hemoglobin per 100 cc. of blood) to appear in these anemic (10 gm. of hemoglobin per 100 cc. of blood or below) patients has for some time been appreciated by the surgeon and anesthesiologist alike. However, too little concern has been given to the fact that these anemic patients almost always are suffering from hypoproteinemia, and when this is combined with marked weight loss, they are

suffering from what Clark[2] and his co-workers call "chronic shock." The essential elements of this syndrome are *loss of weight, decrease in blood volume, decrease of proteins in the blood and an increased volume of interstitial fluid.* These workers emphasized the necessity of giving repeated preoperative blood transfusions in order to restore the blood volume to normal, and they found it necessary on an average to give as much as 2700 cc. of whole blood. The absolute need for this type of preoperative corrective therapy becomes more apparent when one realizes that 500 to 2000 cc. of blood may be lost during major surgical operations. The work of Lyon, Stanton and others[14, 18] should do much to focus our attention on this matter of blood volume for their observations made on postoperative surgical patients suggest that the postoperative blood loss may be an important complication of many surgical procedures. Even though blood loss at operation may be adequately replaced, a further insidious blood loss may occur after operation and this may be considerably larger in amount than the operative loss. This depleted red cell volume shows little tendency to recover spontaneously within the first ten days following operation. Therefore, this problem of preoperative restoration of blood volume to normal and its maintenance during and after operation holds serious implications for those interested in preventing surgical shock and promoting wound healing. Whipple[25] and his associates have shown that in the presence of both a deficiency of hemoglobin and tissue protein, priority is assigned to the fabrication of new hemoglobin. As there seems to be a definite ceiling on the rate of synthesis of new hemoglobin, the time required for the surgical patient to regenerate his own red blood cells and hemoglobin may preclude wound healing. Thus, to insure adequate oxygen-carrying capacity, and adequate blood volume, with its essential protein and hemoglobin mass, more emphasis must be placed on the preoperative, operative and postoperative studies of the circulating blood volume.

Respiration. Our older methods of examining the chest, namely inspection, percussion, auscultation and the use of roentgenograms, have stood the test of time in the detection of pulmonary disease. However, improved methods of evaluating pulmonary function have been sorely needed for a long time. With the increase in the number and gravity of operations on the heart and lungs, the measurement of the patient's vital capacity has shown itself to be an unsatisfactory and even misleading test when considered as a yardstick to predict the patient's ability to withstand operation and anesthesia. Cournand and Richards[4] in their studies on pulmonary function have divided it into two components, ventilation and respiration. Ventilation consists of the gross movement of air or gases into and out of the lungs. This action is mechanical and dyspnea is the symptom of insufficient ventilation. Respiration consists of the gaseous interchange of oxygen, carbon dioxide and nitrogen. The pulmonary alveoli are largely involved in this physiochemical process and cyanosis is the symptom of respiratory insufficiency.

Although these two components of pulmonary function are closely interrelated, certain tests have been devised which allow one to evaluate more accurately the pulmonary function preoperatively. These tests, the maximum breathing capacity, walking ventilation and differential bronchospirometry, when combined with an examination of the chest by fluoroscopy in order that

the rib, diaphragmatic and mediastinal motion may be evaluated, give real insight into the actual status of the patient's pulmonary function.[20, 24]

If use is made of all these special tests of pulmonary function, the surgeon is less likely to produce through operations on the cardiorespiratory system as many respiratory cripples as may result if the tests are not used. In addition, the anesthesiologist can obtain valuable information which will serve as a guide in the choice of anesthetic agents and methods. Finally, a small but constant group of patients will be denied operation when it has been shown by these tests that their remaining pulmonary function would be inadequate to maintain life.

Electrolyte and Fluid Balance. Dehydration may be caused by a simple limitation of fluid intake or by abnormal losses of water and salt through the gastrointestinal tract or by various combinations of both. Clinically, *simple water loss* is characterized by thirst, oliguria and a rising nonprotein nitrogen content in the blood. There is no disturbance in the circulation and the condition is quickly relieved by the administration of water but is adversely influenced by the administration of saline solution. *Pure salt depletion* results in a reduced volume of both plasma and interstitial fluid and is characterized by apathy, lassitude, fainting and peripheral circulatory failure. Thirst is absent in this condition and the clinical picture is indistinguishable from shock that may result from other causes. This type of dehydration is generally relieved by the administration of fluids containing sodium chloride, but occasionally transfusions are necessary to correct the associated loss of plasma protein. These two types of dehydration may occur separately but are more likely to coexist as a result of mixed types of salt and water depletion. These states of dehydration are frequently accompanied by disturbances in acid-base equilibrium.

Treatment of dehydration is usually simple, being corrected by appropriate amounts of normal saline, Ringer's solution or 5 per cent dextrose in water when given intravenously.[6, 19] It has been thought that normal saline would correct the alkalosis of pyloric obstruction and that acidosis could be combated by sodium lactate or, when one is confronted with hepatic insufficiency, sodium bicarbonate. More recent studies have shown that these older ideas of treating dehydration may leave much to be desired and may even result fatally when viewed in the light of recent knowledge. Investigators have pointed out the importance of potassium in the fluid and electrolyte balance.[5, 12] Patients suffering from intestinal obstruction, advanced cancer, biliary disease and vomiting may show incipient degrees of potassium depletion. To date our therapy has been aimed at the correction of measurable extracellular deficits of sodium chloride and bicarbonate while little thought and almost no therapy have been directed toward the intracellular electrolyte pattern of potassium, phosphate, sulfate and magnesium After extensive research on the subject, Moore[15] believes that parenteral provision of these substances may be indicated in three situations met in surgical practice. (1) the chronic intracellular potassium deficit, (2) differential intracellular potassium deficit and (3) the acute extracellular potassium deficit. Each of these conditions requires a modified and cautious form of treatment with parenteral potassium-containing fluid. The entire field of fluid therapy and electrolyte balance, when viewed from the standpoint of the critically ill patient who is suffering from multiple deficiencies (electrolytes,

fluid, proteins, vitamins and so forth) has been altered as a result of these newer concepts concerning the role of potassium. Therefore, the clinician must read and reread the available research and clinical papers on this new and important aspect of modern therapy.

The Central Nervous System. In clinical anesthesia, our major concern is the maintenance of an uninterrupted supply of oxygenated blood to the brain. This allows for narcosis without oxygen lack. It has been shown that a rise in cerebrospinal fluid pressure such as that produced by a brain tumor is associated with a progressive increase in cerebrovascular resistance, in mean arterial pressure and, above a certain level, with a definite decrease in cerebral blood flow. An investigation of cerebral metabolism in patients suffering from diabetic acidosis revealed an interesting finding.[13] Coma was associated with and probably the result of a 40 per cent reduction in cerebral utilization of oxygen which occurred in spite of a generally augmented cerebral blood flow and a normal arterial oxygen saturation. This knowledge clearly delineates the anesthesiologist's problem when dealing with such patients. All available methods known to reduce cerebrospinal fluid pressure should be employed before anesthesia is instituted. Ventricular decompression performed under local anesthesia may prove life-saving by reducing intracranial pressure. A clear airway, oxygen enriched anesthetic atmospheres and light stages of anesthesia are of paramount importance in the management of all patients suffering from increased intracranial pressure.

The Gastrointestinal Tract. The function of the gastrointestinal tract is to provide for the intake, digestion and preparation for assimilation of our daily food requirements (carbohydrates, proteins, fats, vitamins, minerals and water). To accomplish this, normal gastrointestinal function must be maintained and the various secreting structures—salivary glands, stomach, pancreas and liver—must provide an uninterrupted supply of digestive juices in order that the food may be rectified and made ready for assimilation. The presence of certain pathologic processes (obstruction, hemorrhage, infections, and so forth) in the gastrointestinal tract may lead to dehydration, weight loss, malnutrition, hypoproteinemia, avitaminosis and anemia which cause the patient to seek surgical aid

It is obvious that these disturbances should be corrected in so far as possible before the operation. The administration of glucose, saline and amino acids by the parenteral route has proved to be extremely helpful but not the complete answer. When all nourishment must be given by this method, seldom does the patient actually receive his daily caloric requirements and even though the amino acids may keep the patient in positive nitrogen balance, it is just about impossible to make him gain weight on such a regimen. Therefore, whenever possible, a high carbohydrate, high protein, high vitamin, low fat diet should be given by mouth, even resorting to constant gastric drip as advocated by Varco[21] to maintain adequate nutrition. Human albumin is valuable as a means of supplying much needed protein, but even this will fail in the presence of severe liver damage as the available protein cannot be properly metabolized. Our best single rapid method of combating anemia, hypoproteinemia, and diminished blood volume is by the use of massive whole blood transfusions.

PREMEDICATION

Past experience has demonstrated the wisdom of administering preanesthetic medication to all patients before they are anesthetized. This medication is considered essential as it decreases apprehension and fear, produces amnesia, decreases reflex irritability, thus lowering the metabolic rate, and thereby reduces the amount of anesthetic required. When the premedication has been allowed to exert its effect, induction of anesthesia may be carried on in a safer and more comfortable fashion as the excess flow of saliva is inhibited and the respiratory irregularities of the excitement stage are eliminated or modified.

As more than one pharmacologic response is desired, it is common practice to use a combination of drugs for preanesthetic medication. Morphine is used for its sedative and analgesic effects, atropine or scopolamine to inhibit the parasympathetic system and produce amnesia and a short-acting barbiturate to promote hypnosis.

Analgesic and Sedative Drugs. Morphine sulfate (or pantopon hydrochloride) in the average adult dose of 1/6 to 1/4 grain (10 to 15 mg.) is usually injected hypodermically one to one and a half hours before induction. Dripps and Comroe[9] and Drew, Dripps and Comroe[8] have shown that morphine, when given intramuscularly, has its maximal depressive effects on respiration in thirty to thirty-five minutes as against three to seven minutes when it is given intravenously. Morphine has definite advantages as a preanesthetic agent. It relieves pain, decreases anxiety and lessens the tendency of the patient to become excited or delirious and to struggle during induction. This leads to a smoother, more rapid and safer induction. While depressing reflex irritability, morphine decreases the amount of anesthetic needed to produce surgical anesthesia.

Morphine does have certain disadvantages. It is constipating and decreases the value of pupillary signs as a guide to stages of anesthesia through the myosis produced. This myosis takes precedence over the midriasis of atropine when the two drugs are used in combination. Unless the premedication is administered well in advance of induction, depression of respiration may slow induction because of the lessened respiratory minute volume and, furthermore, the maximum respiratory depression due to these sedative drugs may coincide with that of the deep stages of anesthesia.

Belladonna Derivatives (Atropine and Scopolamine). Atropine sulfate (or scopolamine hydrobromide) is usually given hypodermically in 0.32 to 0.43 mg. (1/200 to 1/150 grain) doses. Pharmacologically, atropine depresses the secretions of the respiratory tract and salivary glands but, almost as important, it acts as a mild respiratory stimulant.[23] The maximum effects are generally noted in the first hour and a half, and recovery seems to be gradual, reaching completion in six hours. Atropine causes its most profound effect on the circulatory system, which is usually manifested by an initial tachycardia, slight changes in blood pressure are seen and moderate stimulation of respiratory function is noted. Flushing of the face and a moderate increase in the size of the pupils are generally seen. Scopolamine has its greatest effect on the respiratory function, causing wide individual variations in respiratory rate and tidal exchange, resulting in a definite increase in minute volume. In quantitatively identical doses, the drying effects on the mucous membrane of the mouth and pharynx

are more profound with scopolamine than they are with atropine. When large doses of scopolamine or atropine are used, the addition of morphine does not combat the excessive pulse rate or blood pressure effects of atropine, nor does *the addition of atropine change but slightly the* depressing effects of morphine on minute volume respiration. The combination of morphine and scopolamine in a ratio of 25 to 1 does not change the effect of either drug individually on pulse or blood pressure. The effect of this combination on minute volume respiration, however, resulted in less depression than morphine alone or the morphine-atropine combination, and the recovery from large doses of morphine-scopolamine occurred two hours sooner than when morphine-scopolamine was used. Atropine or atropine and morphine has a greater average effect on pulse rate than morphine or scopolamine alone or in combination. Likewise, morphine *and scopolamine in a ratio of 25 to 1 produces the least amount of deviation from* normal on the minute volume of respiration.

Barbiturates. The use of barbiturates to promote amnesia has increased as have the available proprietary preparations on the market for this use. Generally, a barbiturate is administered the night before operation to promote sound sleep. Many anesthesiologists combine a barbiturate with morphine and scopolamine as a part of the preanesthetic medication, administering it one to two hours before the anesthetic is to be given. Pentobarbital sodium (nembutal) is now being used intravenously in obstetrical anesthesia along with scopolamine. *It is also being used by the intravenous route in combination* with curare for endotracheal intubation prior to nitrous oxide anesthesia. Another use for intravenous pentobarbital sodium is to fortify light premedication, especially when a weak gas such as nitrous oxide or ethylene is to be used for induction. We have found it very useful when administered intravenously for the production of amnesia during spinal anesthesia.

Premedication for Obstetrical Anesthesia and Analgesia. Hershenson[11] has pointed out that premedication in obstetrics must meet the following requirements first and foremost, it must meet the desires and welfare of the mother and her baby; second, it must meet the requirements of the obstetrician and third, the objectives of the anesthesiologist.

Any evaluation of drugs used to produce analgesia and anesthesia in obstetrics is worthless if in the final analysis a careful and detailed study of their effects on the mother and her baby is not made.[17] As almost all drugs administered to the mother traverse the placental barrier and produce an effect on the baby, we can generally evaluate them before the child is delivered by observing their effects on his movements and heart rate. Once the child is delivered, the best guide to the effect the various drugs have had is by noting the length of time required for spontaneous breathing to take place and the number of babies that require resuscitation. Even more useful is a careful check of the number of babies who are found to be depressed after they are returned to the nursery, as some of the drugs used in modern obstetrics and anesthesia have the ability to produce delayed types of depression in the baby

Many varieties of premedication for obstetrics are being used over the country. No definite conclusions can be drawn at present as to which is best. All drugs are dangerous to mother and baby, especially if used to excess, and we all know

how difficult it is to predict an individual's response. Deliveries accomplished under little or no premedication or as little as possible seem to produce the smallest number of adverse reactions in the baby. Premature babies have the greatest chance of survival if the mother is delivered without medication and some form of regional anesthesia is employed (spinal or local infiltration). This seems to be true for the pre-eclamptic, eclamptic and diabetic mother as many obstetricians are employing cesarean section on these problem cases in order to reduce to a minimum the fetal mortality.[10]

There seems to be no uniformity of opinion among obstetricians and anesthesiologists as to the best drugs to use for medication. Scopolamine and apomorphine combinations plus minimal amounts of barbiturates are advocated by some while others feel that intravenous demerol-scopolamine[1] has much to offer. Paraldehyde and barbiturates find favor with a few,[7] while scopolamine and intravenous nembutal (pentobarbital sodium[22]) are also being tried.

SUMMARY

The role of the anesthesiologist in the preoperative preparation of surgical patients is discussed.

Certain important newer developments which allow for a more accurate evaluation of the patient's true physiologic state are presented.

The clinically significant pharmacology of the more commonly used preanesthetic drugs is reviewed.

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TECHNIC OF ENDOTRACHEAL ANESTHESIA

MORRIS J. NICHOLSON

The maintenance of a free airway should always be the first consideration in the administration of a general anesthetic. The danger of complete respiratory obstruction has for ages been recognized by laymen and physicians alike.[2] But

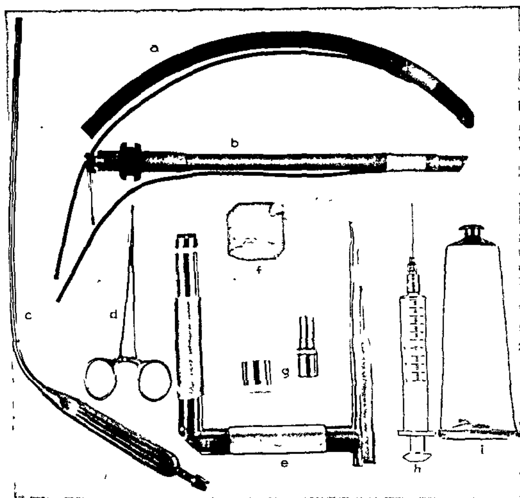


Fig. 448. Equipment commonly used for endotracheal intubation. *a*, Rubber endotracheal tube (Magill) with cuff. *b*, Flexible metal endotracheal tube (Woodbridge) with cuff. *c*, Metal suction tip. *d*, Hemostat used to clamp tube after cuff has been inflated. *e*, "U" shaped laryngoscope (Eversole). *f*, Lead plate to protect teeth. *g*, Universal metal adapter. *h*, Syringe for inflating cuff. *i*, Lubricant.

the cumulative effects of partial respiratory obstruction have often been overlooked and it is not unlikely that many surgical difficulties, postoperative complications and even fatalities attributed to the operation or the anesthetic agent have been primarily due to the anesthetist's failure to provide an unobstructed

Originally published in Surgical Clinics of North America, 29 941–961 (June) 1949.

airway. Because the endotracheal method of inducing anesthesia provides an assured airway at all times and, in addition, makes it possible to administer an anesthetic without a face mask, its popularity and use have steadily increased. Endotracheal anesthesia is indicated for head and neck operations, especially those of the mouth and nose; for certain thoracic and abdominal operations and for operations in which respiratory difficulties exist or may be encountered.

In this paper a detailed description of the methods by which endotracheal intubation can be accomplished will be given and along with this, a discussion of the equipment and anesthetic agents used will be included.

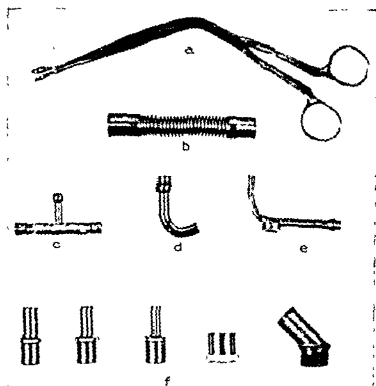


Fig. 449 Equipment occasionally used for endotracheal anesthesia. *a*, Magill endotracheal forceps. *b*, Flexible metal connecting piece. *c*, Ayre's tube. *d*, Magill metal elbow. *e*, Angular finger valve for suction or insufflation. *f*, Variety of metal endotracheal adapters.

EQUIPMENT

The essential equipment for endotracheal anesthesia consists of a laryngoscope and any one of several types of endotracheal tubes.

Accessory equipment, not absolutely essential but often quite helpful, is as follows a small lead plate to protect the patient's teeth, atomizers, straight and curved types, inflatable cuffs, a long rigid suction tube, urethral catheters sizes 14 and 16 French for the aspiration of mucus and debris from the endotracheal tube, metal adapters to couple the endotracheal tube to the anesthetic machine and a nonirritating lubricant with a melting point below the body temperature (Figs. 448 and 449). Helpful but not nearly as essential as the above-mentioned equipment are intubation forceps, flexible metal connectors, several types of Ayres tubes and various sizes and shapes of metal endotracheal adapters.

Laryngoscopes, now in common use, fall into one of two groups according to their shape, the U and the L type (Fig. 450). The blade of the L type

laryngoscope forms an angle of 90 degrees or less with the handle. The blade of the U type laryngoscope is joined by one part of the handle to form a right angle and the U shape is completed by the second part of the handle joining the first at a right angle. The shape of the U type laryngoscope is such that effective lifting motions required for exposure of the larynx can better be applied to the blade. When this lifting motion is attempted with the L-shaped instru-

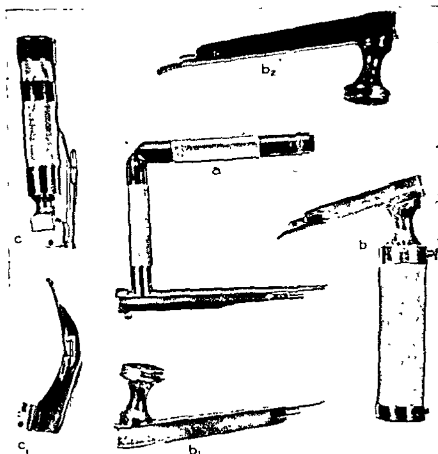


FIG. 450. Laryngoscopes in common use. *a*, Eversole "U" shaped. *b*, Guedel "L" shaped with small medium (b_1) and large (b_2) blades. *c*, Folding laryngoscope with Miller infant blade attached, c_1, Macintosh blade which also may be attached to a small handle. (Foregger Company.)

ment there is a strong tendency to use leverage and damage the teeth by using them as a fulcrum.

The Eversole laryngoscope shown in Figure 450 combines most of the advantages of the laryngoscope popularized by Jackson,[5] which are a narrow blade, U shape, and a removable slide which will occlude the channel so as to prevent the tongue or a single tooth from bulging into the lumen of the instrument and obstructing the view. In addition, the Eversole laryngoscope has a battery and a switch in the handle so that a separate battery box and light cord are not needed. This gives a compact instrument which is ready to be used at any time. Laryngeal exposure has been accomplished on children as well as adults with this instrument and, in our hands at least, these exposures are accomplished more readily and with less trauma than when some of the specially modified laryngoscopes which are said to have special features of design are used.

ENDOTRACHEAL TUBES

Figure 451 shows a variety of endotracheal tubes now in general use: (1) Woodbridge (spiral metal wire with metal tip and hilt covered with Penrose rubber tubing); (2) spiral metal wire embedded in rubber; (3) silk-woven; (4) plastic (portex); (5) rubber (Magill), and (5, *a*) rubber (Magill) with built-in cuff.

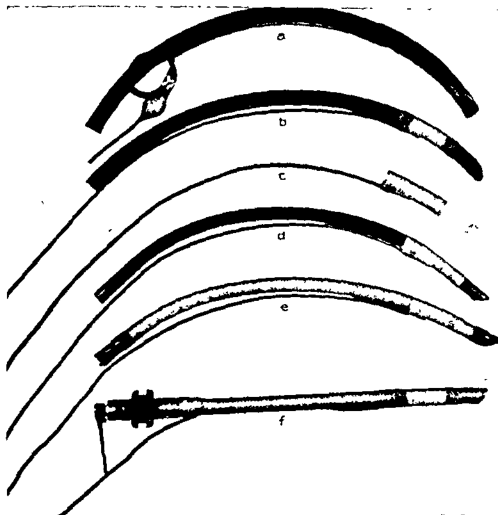


Fig 451. Endotracheal tubes now in common use. *a*, Magill—rubber with built-in cuff. *b*, Magill—rubber with inflatable cuff. c, Portex—plastic with inflatable cuff. *d*, Woven silk with inflatable cuff. *e*, Spiral wire embedded in rubber with inflatable cuff. *f*, Woodbridge (spiral wire with metal tip and hilt covered with Penrose tubing and inflatable cuff attached).

Woodbridge Tube. The spiral wire endotracheal tube designed by Flagg[1] and modified by Woodbridge[9] is widely accepted. It consists of a metal hilt and a small metal tip with coiled wire connecting the tube. These tubes are held straight and rigid by means of a hollow stilet which facilitates their handling during intubation. They are strong and flexible without a tendency to obstruct by kinking or compression. Because of the strong material used in their construction, the walls can be thin so that the internal diameter or breathing space is greatest in proportion to their external diameter. Penrose tubing is used to cover these spiral wire tubes to prevent the mucous membrane from being caught in the coils, and also to make them air-tight. The metal hilt provides a

place for the attachment of an adapter in order to connect the patient to the anesthetic supply. It also provides a place for the attachment of a rubber spool which fits between the patient's teeth and protects them from injury when closed on the metal. These tubes are manufactured in two lengths. The short tube can be used beneath the anesthetic mask or with an adapter and an inflatable cuff to provide a closed system. The long tube is designed for use with an inflatable cuff and an adapter when it is desirable to remove as much as possible of the anesthetic equipment from the immediate region of the patient's mouth.

Plastic (*Portex*).* Plastic (portex) tubes have found a large field of usefulness (Fig. 452). They are relatively inexpensive, durable and are manufactured in practically every size one could possibly need. They have a relatively large bore but their walls are very resistant to kinking, and this makes them particularly valuable in the small sizes for pediatric anesthesia. They may be used repeatedly, with inflatable cuffs attached, to provide an air-tight system as they almost never develop a leak in their walls. Once the tube is introduced into the trachea and it reaches body temperature it becomes more flexible and molds itself to fit the natural configuration of the airway. When they are used, care must always be exercised, as it must with all endotracheal tubes that do not have metal hilts, to prevent their becoming obstructed by the closure of the patient's teeth.

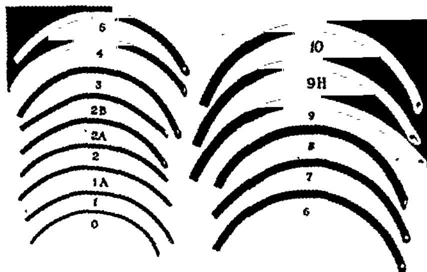


Fig. 452. Portex (plastic) endotracheal tubes, note fifteen different sizes.

Rubber. Rubber tubes used for endotracheal anesthesia are generally associated with the name of Magill[8] who popularized their use in England. These tubes are now made of a special mineralized rubber designed to remain resilient in spite of their thin walls. They are curved to conform to the nasal fossa, but they are equally suitable for nasal or oral intubation. They may be obtained with either thick or thin walls. The thick-walled tubes are used for oral intubation and the thin-walled variety has been designed for nasotracheal intubation. These tubes should not exceed in length twice the distance from the lobe of the ear

* Manufactured by Portland Plastics, Ltd., Dover, Kent, England.

to the ala of the nose in order to prevent their being introduced into the right main stem bronchus. They are easy to clean, can be sterilized by boiling and are quite durable. One end is beveled so that the point is to the right when viewed from its concave aspect. When these tubes are fitted with an inflatable cuff of the Guedel-Waters[3] type and passed through the nose, a closed system can be provided for surgery in the mouth. More recently, a specially designed Magill tube with a built-in inflatable cuff has been manufactured, as shown in Figure 451, for this particular purpose. Once these tubes are in place and the cuff inflated, the aspiration of blood and mucus is prevented. One disadvantage to the use of these tubes is that they may become obstructed either by kinking when the head is rotated or flexed to an exaggerated degree, or by closure of the patient's teeth upon them when they are used by the orotracheal method. The aspiration of mucus, blood or debris from the tracheobronchial tree is not as readily carried out through them as through the spiral wire tubes, and a nasal hemorrhage is not uncommonly associated with their passage through the nose.

Woven Silk. Woven silk endotracheal tubes, formerly manufactured in France and now almost impossible to obtain in America, are somewhat stiff-walled but flexible, with a smooth outer and a rough inner surface. These tubes cannot be sterilized by boiling because of the shellac used in their construction, but must be soaked in an antiseptic solution. They may be fitted with an inflatable cuff and used for oral or nasal intubation.

Spiral Wire. Tubes formed of spiral wire embedded in rubber possess many of the good qualities of the ordinary spiral wire tube covered with Penrose tubing. However, they also lack a metal hilt, as do the plastic, rubber and woven silk catheters, for the attachment of an adapter or a rubber spool so as to connect them to the anesthetic supply and to prevent the patient from biting them.

ANESTHESIA

Endotracheal intubation may be readily accomplished under topical anesthesia and this method of intubation is indicated for patients suffering from suppurative pulmonary disease. If a general anesthetic is used for intubation, the induction period is often associated with an accumulation of fluid in the air passages large enough to dangerously hamper respiratory exchange. When the intubation has been done under topical anesthesia, before induction of a general anesthesia is started, this fluid can be removed as it accumulates by aspirating through the tube. Patients with partial respiratory obstruction from intrathoracic goiter, cancer of the thyroid, unilateral or bilateral paralysis of the recurrent laryngeal nerve and those with cardiac disease who show markedly reduced vital capacities constitute another group for whom endotracheal intubation under topical anesthesia is indicated as none of them can well withstand even the slight respiratory obstruction so often associated with the induction of general anesthesia.

Adequate preliminary medication and gaining of the patient's confidence are prerequisites to successful intubation under topical anesthesia. After anesthetizing the vestibule of the nose by spraying it with 10 per cent cocaine or 1 per cent pontocaine hydrochloride, a curved Rowbotham atomizer (Fig. 453) may be passed through the nasal cavity so as to anesthetize the nasopharynx (Figs

ig. 453. Atomizers. *a*, Straight Rowbotham. *b*, Curved Rowbotham. *c*, Straight DeVilbiss.

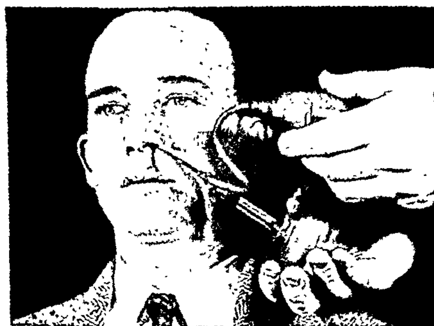


Fig. 454. Position of operator when curved Rowbotham atomizer is used to anesthetize the nasopharynx.

454 and 455). With the atomizer in place, the epiglottis and larynx are anesthetized by coordinating the spraying with the patient's inspirations. Any atomizer may be used, but the Rowbotham is especially designed for this purpose. Blind nasotracheal intubation may be carried out as described later, or the larynx may be exposed with the laryngoscope, its anesthetization completed with a long, straight Rowbotham* or DeVilbiss† atomizer (Fig. 453) and the intubation performed under direct vision. The topical application of cocaine to the superior laryngeal nerves at the piriform sinus with the curved throat forceps is an additional aid in producing good anesthesia. If bronchoscopy is to be done before the intubation, 5 cc. of a 2 per cent cocaine solution dripped into the larynx from above or 30 mg. of pontocaine hydrochloride in 9 cc. of physiologic saline

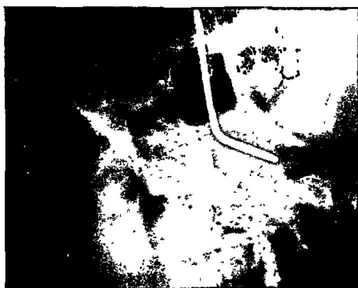


Fig. 455. Location of the tip of the curved Rowbotham atomizer in the nasopharynx as shown by lateral roentgenogram of skull.

solution injected into the trachea through the cricothyroid membrane provides adequate anesthesia of the tracheobronchial tree for this procedure.[4]

When general anesthesia is desired for endotracheal intubation, it may be produced by ethylene, cyclopropane or ether, singly or in combination with avertin, nitrous oxide or intravenous sodium pentothal. The routine use of 10 per cent cocaine topically to the larynx and trachea is helpful regardless of which one of the general anesthetic agents is to be employed This added topical anesthesia decreases much of the coughing or apnea seen after stimulation of the larynx or trachea Skillful induction is more important than the agent used or the actual intubation itself. Intubation is greatly facilitated if the depth of anesthesia is such that pharyngeal and laryngeal reflexes are abolished and the cords abducted. When these conditions exist, intubation may be carried out before sensation reaches the larynx and the muscles lose their relaxation. This does not mean that deep anesthesia is required but it does presuppose that relaxa-

* Manufactured by Frank Rogers, 1 Beaumont Street, London, England.

† Manufactured by the DeVilbiss Company, Toledo, Ohio—Number 151 Physicians Atomizer

tion of the jaw will be obtained and that the entire act of intubation will be executed with deft, premeditated accuracy.

INTUBATION

Nasotracheal Method. Endotracheal intubation may be performed either through the nose or through the mouth. The nasal route is indicated for certain oral operations, because the mouth is left free, and for certain plastic procedures about the face, especially the lower lip. This method is valuable for patients with ankylosed jaws when orotracheal intubation is impossible.

The blind method of nasotracheal intubation is frequently successful without recourse to the laryngoscope, and is worth while attempting if the proper conditions exist. The nose should be examined beforehand in attempt to determine which nostril offers less obstruction to the passage of the tube. The endotracheal tube should never be forced through the nares when resistance is met as this almost inevitably results in nasal hemorrhage which complicates the entire procedure. The head should have the same relation to the neck and trunk in the recumbent as in the erect position, and a pillow is generally required below the occiput. Magill described the ideal position of the head as the one a man unconsciously and instinctively takes in the normal erect position when he wishes to "sniff the air." This throws the cervical vertebrae in normal relationship with the dorsal vertebrae, head slightly extended on the atlas, with the mandible approximately at a right angle to the table, and the air passages from nose to glottis as free as possible. After preliminary cocainization of the selected nostril, nasopharynx and larynx, the tube is often tolerated without coughing, even under light anesthesia. The cocainization not only anesthetizes the mucous membrane but, through its shrinking effect on nasal tissues, increases the space available for the passage of the tube and decreases the possibility of epistaxis.

Although blind intubation can be performed under topical or any plane of general anesthesia, there is a decided difference of opinion as to the influence of the plane of anesthesia on the ease of intubation. Magill believes that it is easiest before the onset of relaxation as the neck muscles draw the epiglottis forward, out of the line of the glottic opening. Some anesthetists believe that relaxation facilitates nasal intubation. Lundy[7] has found that nasal intubation can often be accomplished if it is synchronized with the first respiratory movements after respiratory obstruction has been produced by depressing the chin. During this period of respiratory obstruction the carbon dioxide content of the blood is elevated and the pharyngeal muscles are tensed to carry out the much needed inspiratory phase of respiration. When the chin is elevated and the obstruction relieved, the tube is guided into the trachea by the action of the pharyngeal muscles during inspiration.

With the head in the described position, the proper sized endotracheal tube is lubricated and passed through the vestibule of the nose so that it passes along the floor of the nostril close to the septum. While the tube is held in the right hand, the left hand is placed so that the fifth finger touches the larynx, the fourth finger holds up the chin, the third finger pushes the lips together, the

index finger compresses the open nostril and the thumb rests on the tip of the mastoid process. With the left hand so placed, the head is firmly held and the respirations must of necessity be carried on through the intubed nostril.

As the endotracheal tube is progressively introduced into the nose, if the anesthetist listens near the open end, the respiratory sounds become louder and louder as the glottic opening is approached. Much of the success of blind nasotracheal intubation depends on the use of these respiratory sounds in guiding the tube into the larynx, and normal respiratory exchange is necessary. If the tube fails to enter the trachea, it usually enters the esophagus or goes laterally into the piriform sinus; in either case the respiratory sounds disappear and no air passes through the tube. Withdrawal of the tube until respiratory sounds are again heard, then rotation from side to side, as indicated, to return the tip of the tube to the midline may be tried. Occasionally, gentle manipulation of the larynx with the little finger of the left hand may be required in addition. Use of the opposite nostril occasionally brings success as, at times, does elevation of the head on the trunk.

If the above-mentioned maneuvers fail after several attempts to place the endotracheal tube in the trachea, the larynx should be exposed with the laryngoscope, the tube grasped with suitable forceps and directed into the glottic opening.

Frequently, when the nasotracheal method is to be employed, intubation is carried out after the larynx has been exposed with the laryngoscope and the larynx cocainized, no attempt being made to introduce the tube blindly.

Oral Endotracheal Method. There are three varieties of the oral endotracheal methods of intubation. The first in which the endotracheal tube is inserted straight through the laryngoscope after the larynx has been exposed is called the direct method and will be described in detail later.

Indirect Method. The second in which the endotracheal tube is inserted outside or around the laryngoscope without the larynx being under direct vision is called the indirect method. Occasionally this method is valuable when full view of the larynx is obstructed by an intra-oral tumor or by an extra-oral mass, such as a large adenomatous goiter displacing the larynx and trachea from their normal confines. When the epiglottis is located, it can be elevated slightly or a curved Magill tube may be directed under the epiglottis and into the larynx.

Blind Intubation by Touch. The third variation, blind intubation by touch, has been developed and used by only a few anesthetists. This technic demands deep anesthesia with complete relaxation, the possession of fairly long fingers by the anesthetist is extremely helpful. Although this method is much more useful in children than in adults, every anesthetist should be acquainted with it as a life may be saved from the timely introduction of an endotracheal tube during an emergency when a laryngoscope is not available.

The anesthetist stands facing the patient and on the right side (if he is right handed). The mouth is opened wide with the mouth gag and the tongue is pulled well forward. The left index and middle fingers are passed into the mouth along the dorsum of the tongue and the epiglottis is palpated. It is elevated and the arytenoid cartilage is located with the middle finger. Then the tube is passed into the mouth along the groove formed by the index and middle

finger. A Magill or woven-silk catheter bent in almost a quarter circle functions best for this type of intubation.

Direct Method. As mentioned previously, in the direct method of intubation the larynx is exposed by means of a laryngoscope and the endotracheal tube inserted through the speculum into the larynx under direct vision. Although this procedure may be done under topical anesthesia, it is more often performed after the patient has been anesthetized with some general anesthetic agent. Laryngoscopy should not be attempted until anesthesia has been deepened to the point that the masseter muscles are relaxed and the pharyngeal and laryngeal reflexes suppressed.

POSITION OF THE PATIENT'S HEAD

Jackson[6] has described two positions of the patient's head on the table, either of which tends in certain respects to facilitate the laryngeal exposure. The position of choice is the one which best suits the anesthetist's needs and this will, in a measure, be influenced by the method followed in introducing the laryngoscope.

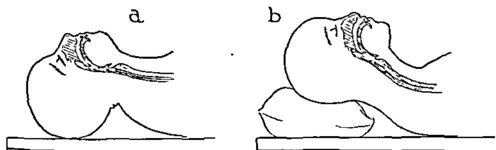


Fig 456. Position of head for laryngoscopy. *a*, "Classical," *b*, amended.

These positions of the head are the "classical" described in 1913 by Jackson and his newer or amended positions (Fig. 456). In the classical position the patient's head must be in full extension, with the vertex firmly pushed down toward the feet so that the mouth opens and the tongue drops down. In this position the neck muscles are on the stretch and the distance from the teeth to the glottis is increased In the amended position, the head is raised 10 cm. above the level of the table and slightly extended so that the neck muscles are relaxed and the distance from the teeth to the glottis is decreased. When the amended position is used, the mouth does not fall open and the blade of the laryngoscope or the index finger of the right hand is inserted into the mouth to push the tongue forward, making room for the passage of the laryngoscope. The other manipulations of the laryngoscope are the same as when the classical position is used.

INTRODUCTION OF THE LARYNGOSCOPE

For the mere economy of motion, it is advisable for the beginner to learn to introduce the laryngoscope with his left hand and pass the endotracheal tube with his right hand. More important, however, is that the laryngoscopy be done in an efficient, rapid, but atraumatic manner.

The laryngoscope may be introduced in the midline or from the side of the

mouth. The use of the median line makes recognition of structures easy but involves passing the laryngoscope over the incisor teeth which are more easily damaged than the molars. Furthermore, the exposure of the larynx may be quite difficult or impossible when the central incisors protrude or the mandible recedes markedly. When the more desirable lateral route is used, the laryngoscope enters the mouth at the right corner and passes into the pharynx over the

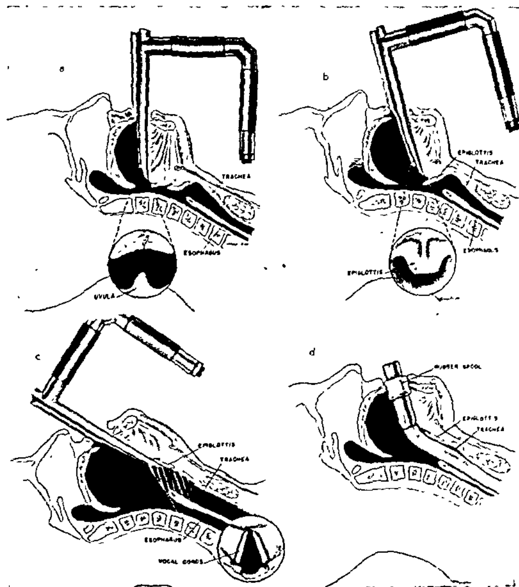


Fig 457. Exposure of larynx for endotracheal intubation. *a*, Laryngoscope introduced into mouth. *b*, Exposure of the epiglottis. *c*, Elevation of the epiglottis with exposure of larynx. *d*, Flexible metal endotracheal tube in place.

molar teeth, while the tongue is displaced to the opposite side and anteriorly. The accompanying illustrations show the laryngoscope being introduced into the mouth by the median route (Fig. 457, *a*). For the sake of clarity the position of the anesthetist's hand and the lead plate used to protect the teeth are not shown.

If the classical position is to be employed, the occiput is pushed downward toward the feet in order to throw the chin up and the mouth open. A lead

plate is placed over the incisor teeth with the right hand while the upper and lower lips are held apart. The laryngoscope, held in the left hand, is passed into the mouth along the dorsum of the tongue. The upper lip is retracted so that it cannot be caught between the speculum and the upper teeth and the fingers of the right hand are used to steady the lead plate while the thumb is placed on the base of the blade and the speculum is gently advanced. With the laryngoscope thus placed in the mouth it is advanced until the base of the tongue and the uvula come into view (Fig. 457, *a*). With the speculum steadied

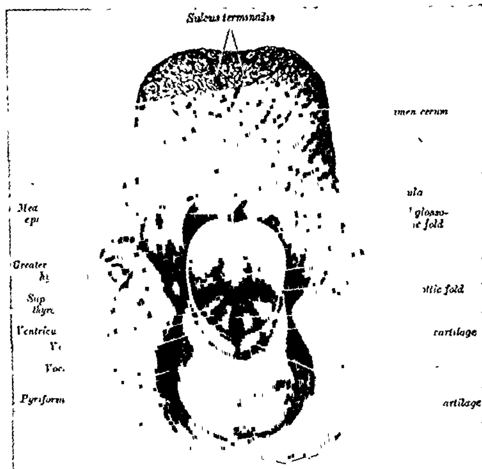


Fig 458 The entrance to the larynx, viewed from behind (From Gray's Anatomy, ed. 25, Lea & Febiger.)

by the thumb and index finger of the right hand, the left hand is shifted to the horizontal bar of the laryngoscope. As the base of the tongue is elevated, the epiglottis comes into view (Fig. 457, *b*). In exposing the epiglottis it is important that the laryngoscope be lifted so that the lower jaw and tongue are displaced forward, increasing the distance between the posterior pharyngeal wall and the base of the tongue. When the speculum of the laryngoscope is incorrectly used as a lever and the teeth are used as a fulcrum in an attempt to accomplish this exposure of the epiglottis, the teeth are likely to be broken. The tip of the speculum is depressed to pass the epiglottis and it is advanced until it is about 1 cm. beyond the epiglottis. With the speculum so placed, the lifting motion is again applied to the laryngoscope, and the larynx should be brought into view (Fig. 457, *c*).

If after this maneuver the larynx cannot be seen, the speculum probably has been advanced too far and has entered the esophagus. The larynx may be exposed from this position, however, by carefully withdrawing the speculum and allowing the larynx to drop down, exposing in order the corniculate, cuneiform and arytenoid cartilages in the glottic opening (Fig. 458). Occasionally the epiglottis may be extremely flexible and when its elevation is attempted, it will fall back on itself and partially or completely obstruct the view of the laryngeal opening. In some patients just the dorsal third or half of the larynx can be brought into view without the use of considerable force on the laryngoscope. If in such a case an assistant will make downward pressure from the outside on the larynx it will help to expose the entire laryngeal opening.

Much difficulty can be prevented in doing a laryngoscopy if the anesthetist will always remember that the epiglottis serves as a fixed landmark, just as the carina does in bronchoscopy and, therefore, the epiglottis should always be exposed and used as a means of orientation. Whenever the anatomy seen through the laryngoscope is unfamiliar, one should again find the epiglottis and re-orient himself.

ANESTHETIZATION OF THE TRACHEA

Laryngeal spasm with its associated spasms of all the muscles of respiration and the ensuing apnea that inevitably occurs can be prevented in most cases if the pharynx, larynx and trachea are sprayed with one of the topical anesthetic agents. This may be done before induction of anesthesia, as described in the paragraph on intubation under topical anesthesia, or it may be carried out after the larynx has been exposed. The tip of the long, straight atomizer, either Rowbotham or DeVilbiss as shown in Figure 453, is passed through the laryngoscope between the abducted cords, and the trachea sprayed. The tip of the atomizer is then withdrawn and the larynx and posterior pharynx are sprayed. When done in this order the trachea is sure to be anesthetized, but if the larynx is sprayed first, the cords are likely to close when hit by the spray of local anesthetic agent and, consequently, none of it will reach the trachea. When the patient is under general anesthesia, I believe it is a waste of time to spray an anesthetic agent on the cords and trachea and follow this immediately with the introduction of the endotracheal tube. Insufficient time is thus allowed to elapse and no real anesthetization is gained by the topical application. A much better plan is to remove the laryngoscope after the cocainization, continue the administration of the general anesthetic for another three to five minutes, allowing the topical agent to produce its effect, and then, on re-exposing the larynx, introduce the tube and, in this fashion, gain the benefit of the depressed reflex irritability of the larynx and trachea.

INTRODUCTION OF THE ENDOTRACHEAL TUBE

When a clear view of the trachea has been obtained and its anesthetization completed, an endotracheal tube previously lubricated is slipped through the glottis into the trachea (Fig. 457, *d*). If there is movement of the cords, the time when they are in greatest abduction should be chosen for intubation. The catheter should be passed with one rapid, gentle motion, touching the cords

as little as possible. If the tube is passed at the side of the laryngoscope, the view of the cords remains unobstructed and the tube approaches them from behind and to the right, but when the tube is passed directly down the speculum of the laryngoscope, and the cords are observed through the stilet, the view of the cords is lost when the tip of the tube passes the light of the laryngoscope. Trauma to the cords should be avoided as a break in the mucous membrane covering them is likely to be followed by infection which leads to granulomatous polyps and changes in voice, and subsequently surgical removal of these growths may be required to restore the voice to normal.

WITHDRAWAL OF THE LARYNGOSCOPE

After the tube has been passed into the trachea it is held in place with the right hand while the left hand gently withdraws the laryngoscope. The lead plate is then removed and the rubber spool on the hilt of the tube is adjusted between the teeth to prevent the patient from biting the tube (Fig. 457, *d*). It is well to listen near the end of the tube where the strong expiratory phase of respiration, with its accompanying blast of air, can be heard. This gives real assurance that the tube is in the trachea and not in the esophagus.

SPECIAL CONSIDERATIONS

An endotracheal tube may be used just to insure a clear airway during a thyroidectomy, neck dissection or similar operation, and the mask may be placed over it just as is done when an oral or nasal airway is employed. Anesthesia may be administered without a face mask by using the Guedel-Waters inflatable cuff on the endotracheal tube and connecting the tube to the anesthetic supply by an adapter. Adhesive tape is used to hold the tube in place to prevent the spool from slipping out from between the teeth. When an operation is to be performed on the face, it is helpful to use the long Woodbridge tube with an endotracheal cuff and an adapter This long tube may be brought out the corner of the mouth on the side opposite the operation, thus allowing the surgeon ample room. In the absence of an endotracheal tube with an inflatable cuff, packing of the oral pharynx with lubricated moistened gauze strips is advocated by some. This should be done with caution as it is necessary to pack the pharynx very firmly to secure an air-tight fit. This packing may cause pressure necrosis in the tonsillar area and a subsequent sore throat if the operation lasts more than two hours. Another disadvantage to the use of an oral pack is that aspiration of vomitus into the trachea is still possible; this is avoided, however, when an inflatable cuff is used.

PROLONGED USE OF ENDOTRACHEAL TUBES IN COMATOSE PATIENTS

After a rather large experience with the use of endotracheal tubes to insure an adequate airway in patients suffering from coma, we have more or less abandoned this procedure in favor of early tracheotomy. Our reasons for doing so are as follows: (1) tracheotomy is more physiologic—the presence of an endotracheal tube acts as an irritant causing a productive tracheobronchitis. (2) Tracheotomy insures a better avenue for the removal of excess secretions by the nursing staff. (3) Alterations have been noted in the tracheal mucous mem-

brane and granulomatous polyps have been seen on the vocal cords following the prolonged use of endotracheal tubes. (4) There is always the possibility of an endotracheal tube becoming obstructed or inadvertently removed and the patient dying of asphyxia; this is much less likely to happen after a tracheotomy has been performed.

MISCELLANEOUS

Before insertion of an endotracheal tube that has an inflatable cuff on it, the cuff should be inflated and inspected for leaks. Over-inflation of the cuff after placing it in the trachea may be responsible for trauma to the tracheal mucosa. Gillespie gives a practical test to ascertain *the minimal necessary pressure.* A dry syringe fitted with a blunt, wide gauge needle is inserted in the inflating tube and the air is gently injected into the cuff while pressure is exerted on the breathing bag. The inflation of the cuff is discontinued as soon as it reaches

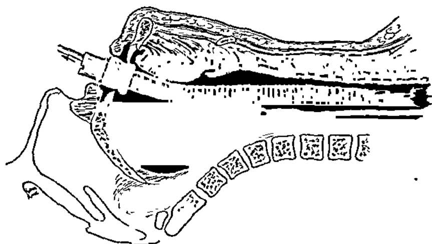


Fig. 459. Catheter passed through endotracheal tube for the removal of mucus from the trachea.

the point where it just prevents the leakage of gas which has been taking place until that time owing to the manual pressure on the breathing bag. Some of the inflatable cuffs are now being manufactured with small pilot cuffs near the distal end of the inflating tube. A relatively good idea of the amount of tension on the cuff in the trachea may be gained by observing the pilot cuff as the air is injected.

When mucus collects in an endotracheal tube during an operation, it may be removed by passing a sterile number 14 or 16 French ureteral catheter into the tube, applying suction and removing the debris (Fig. 459). The same procedure is of extreme importance in removing the pus that accumulates in an endotracheal tube during operations on patients suffering from suppurative diseases of the lungs. We have found a 16 gauge Levin tube, with its distal end prepared so that there is a single end opening, to be of great assistance in removal of secretions from the right and left main stem bronchi during thoracic operations; these secretions cannot be reached with the ordinary ureteral catheter. Small sized polyethylene plastic tubing has proved to be invaluable for the aspiration of mucus from the small bore endotracheal tubes used in pediatric

anesthesia. In severe bronchiectasis or lung abscess it is often advisable to preoperative and postoperative bronchoscopy in order to remove the accumu secretions so that the patient will not drown in them either during inductic during the postoperative recovery.

Although 10 per cent cocaine is advocated and used as a routine topical thetic agent for the endotracheal intubation, undesirable cocaine reaction almost never seen. This may be explained by the fact that all conscious pat are advised and urged to expectorate any excess solution that may pool ir posterior pharynx rather than to swallow it, for it is thought that it is ra

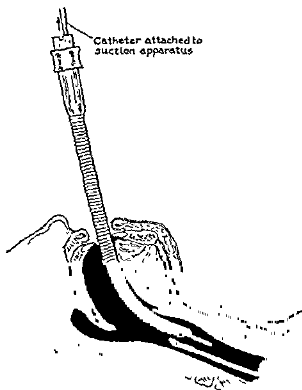


Fig. 460. Aspiration through endotracheal tube during its removal from the trache

absorbed from the stomach; in addition, the cocaine causes vasoconstricti the mucous membrane and this is believed to hinder its absorption. In ad to these above-mentioned features which militate against the occurren cocaine reactions, most of the patients receive some type of general anes and this, of course, depresses the sensitivity of the cerebral cortex to stimul

At the end of the operation certain complications are likely to occur the endotracheal tube is removed. Blood, pus or mucus may be aspirated the trachea unless the nasopharynx is cleared of foreign material by prelim aspiration and a catheter subsequently introduced into the endotracheal tu that it extends beyond the tip and suction applied continuously as the t withdrawn so as to remove any material that may be trapped between the and the tracheal wall (Fig. 460). The pharyngeal toilet and removal c endotracheal catheter will often precipitate a spasm of the glottis if the p is lightly anesthetized. Therefore, I believe that the anesthesia should n too light at the time of extubation. A mouth gag placed between the teetl

metal oropharyngeal tube will prevent the patient from biting the tube and also lessen the possibility of injury to the patient's throat during extubation. The insertion of the pharyngeal airway before the tube is removed will generally prevent the common type of obstruction seen in the anesthetized patient when the tongue is allowed to fall back against the posterior pharyngeal wall.

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TECHNIC OF SPINAL ANESTHESIA

URBAN H. EVERSOLE

The combination of flaccidity of skeletal musculature and contraction of the intestine makes spinal anesthesia very desirable for abdominal surgery. This is the paramount reason for using this type of anesthesia. It is, therefore, the choice when surgery is to be performed in the abdomen. The use of any other type of anesthesia must be for a special reason, usually because of a particular contraindication to spinal anesthesia. With technical improvements and a better understanding of the physiologic phenomena which accompany spinal anesthesia, together with more adequate means of nullifying or circumventing some of the undesirable side effects of this method of anesthesia, the number of contraindications is rapidly shrinking.

Spinal or subarachnoid anesthesia is the anesthesia produced by the injection of a relatively small amount of an anesthetic agent into the subarachnoid space. This agent acts directly on the nerve roots before they emerge from the dura. The extent of the body which is rendered anesthetic is dependent upon the distribution of the anesthetic agent in the subarachnoid space.

Although spinal anesthesia has been employed for surgery in all parts of the body, it is usually considered unsafe for operations above the level of the diaphragm. In recent years there has been a concerted effort on the part of anesthesiologists to devise technics which limit spinal anesthesia more accurately to the area of the body in which the operation is to take place. In other words, instead of giving a single, relatively large dose of the spinal anesthetic agent to all patients and anesthetizing a large area of the body regardless of how limited the actual surgical procedure, the tendency is to try as far as possible to anesthetize only the area to be operated on. Aside from the quite obvious fact that this decreases the amount of anesthetic agent required and hence lessens the danger of toxic side effects, it seems reasonable to assume that there will be less effect on the autonomic nervous system and hence less circulatory and respiratory depression. Furthermore, there is evidence that postoperative neurologic complications may bear a direct relationship to the concentration of the anesthetic drug in the subarachnoid space, and that we may expect a lower incidence of these complications when lower concentrations of the anesthetic drug are used.

Types

For practical purposes, spinal anesthesia may be classified as (1) "low spinal" when the spinal anesthesia does not extend above the umbilicus (tenth thoracic segment); (2) "medium spinal" when the upper limit of the spinal anesthesia

Revision of article originally published in Surgical Clinics of North America, 29.923–940 (June) 1949.

is in the neighborhood of the costal margins (seventh or eighth thoracic segment), and (3) "high spinal" when the upper border of anesthesia extends to the nipple line (fourth thoracic segment). Spinal anesthesia has been employed for many years with uniformly good results for operations on the lower extremities and in the lower abdomen. However, it is only within relatively recent times that technics have been developed whereby this type of anesthesia could be more accurately controlled for upper abdominal surgery. These technics, combined with improved methods for support of circulation and respiration, have made this form of anesthesia much safer for operations in the upper part of the abdomen.

Anatomical and Mechanical Factors

Consideration of some of the anatomical and mechanical factors concerned with the production of spinal anesthesia may be helpful in appreciating the problems of distribution of the anesthetic agent in the subarachnoid space.

A spinal anesthetic agent may be injected at almost any level in the subarachnoid space. In most instances, however, it is considered unsafe to inject the agent higher than the first lumbar interspace because of the danger of injury to the spinal cord. The injection is usually made in either the second or third lumbar interspace. When the anesthetic agent is injected into the lumbar area it is necessary for it to travel a variable distance from the site of injection in order to produce anesthesia at any level more cephalad than the lower extremities or more caudad than the knees. In order to produce anesthesia high enough for upper abdominal surgery, that is for surgery on the biliary tract, the stomach or spleen, or to provide satisfactory anesthesia for a complete abdominal exploration, the level must be as high as the fourth thoracic segment. With the anesthetic agent at this level, the approximate level of surface anesthesia is the nipple line anteriorly. For satisfactory spinal anesthesia for surgery in the lower abdomen, surface anesthesia should be as high as the costal margin anteriorly. This represents the eighth thoracic segment and is not high enough to permit complete abdominal exploration without discomfort to the patient and, furthermore, they may have pain with traction on the viscera. Anesthesia at this level is usually satisfactory for such operations as appendectomy and hysterectomy. In order to have surface anesthesia to the level of the umbilicus, the agent must be as high as the tenth thoracic segment. This level permits superficial operations on the lower abdomen and is usually quite satisfactory for inguinal herniorrhaphy. With the anesthetic agent at the level of the first lumbar segment, anesthesia will be confined to the area below the groin and, of course, is satisfactory only for operations on the perineum, anus and lower extremities.

Perhaps a better appreciation of the movement of the anesthetic agent in the spinal canal can be had if we consider the actual distances it must travel from a given site of injection to obtain the various levels of anesthesia. Assuming the site of injection to be the third lumbar interspace, in order to obtain surface anesthesia to the nipple line anteriorly in the average adult male, the agent is present in the subarachnoid space approximately 26 cm. from the site of injection and is 7 cm. above its superficial anterior sensory level. If the upper border of anesthesia is at the umbilicus, the agent is approximately 12.5 cm.

above the site of injection and is 15 cm. above the upper level of skin anesthesia. Even with surface anesthesia only as high as the groin, the agent must have traveled 7.5 cm. cephalad from the site of injection and the entire bulk of the anesthetic agent would be above the level of the surface anesthesia, with

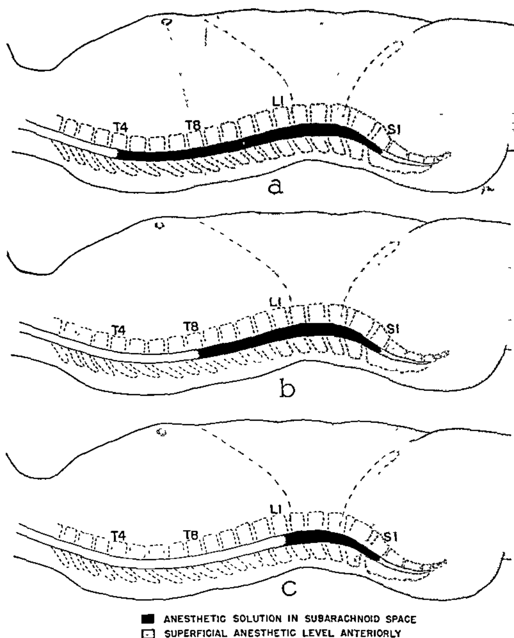


Fig 461. *a*, Anesthetic level necessary for complete abdominal exploration and upper abdominal surgery. *b*, Anesthetic level necessary for lower abdominal surgery. Not adequate for complete abdominal exploration *c*, Anesthetic level necessary for perineal operations and surgery of the lower extremities.

the upper border of the anesthetic agent 18 cm above the upper level of the anterior surface anesthesia.

It is, of course, quite obvious that when spinal anesthesia is high enough to involve the motor roots of the spinal nerves in the thoracic segment of the cord there will be impairment of the activity of the intercostal muscles, and hence, an alteration in thoracic respiration. With motor anesthesia at the fourth thoracic

segment, it has traveled 26 cm. from the site of injection and is only 14 cm. from that level which will result in complete respiratory paralysis. When it progresses far enough cephalad (first thoracic segment) to paralyze all intercostal muscles it is then only 7 cm. from that level which will produce complete respiratory arrest (Figs. 461 and 462). Figure 461, *a*, *b* and *c*, is a diagrammatic representation of the distribution of the spinal anesthetic agent in the subarachnoid space with corresponding sensory surface distribution of anesthesia. Figure 462 is a diagrammatic representation of the proximity of the

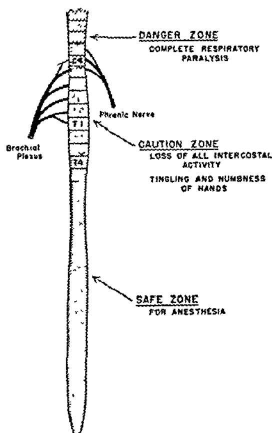


Fig. 462. Diagrammatic section of spinal cord Note proximity of fourth thoracic segment (level necessary for satisfactory upper abdominal surgery) to origin of phrenic nerve.

anesthetic agent for upper abdominal anesthesia to that point which would result in respiratory paralysis.

The signs and symptoms of respiratory depression and paralysis under spinal anesthesia, as well as the treatment of this condition, will be discussed later.

Factors Influencing Height of the Anesthesia

There are many factors that influence the height of cephalad distribution of spinal anesthesia. The more important of these are: (1) specific gravity of the anesthetic solution, (2) position of the patient during and immediately following injection of the anesthetic solution, (3) rate of injection, (4) volume of anesthetic solution injected; (5) barbotage or mixing, (6) spinal fluid pressure, (7) amount of spinal fluid withdrawn, (8) temperature of the solution injected, (9) site of injection, and (10) length of the spinal column. *It is obvious* that all of these factors come into play with every spinal anesthesia although

technics are designed to keep as many of these factors constant as possible and to depend upon only one or two variables to obtain a given height of anesthesia.

A technic has been developed which, so far as possible, depends upon the ratio of the weight of the spinal anesthetic solution to that of the spinal fluid. This makes it possible for most of the factors influencing the height of spinal anesthesia to be kept relatively constant and to utilize the force of gravity to determine the distribution of the anesthetic agent in the subarachnoid space. This is accomplished by adjusting the position of the patient during the early period following the injection of the agent into the subarachnoid space. It is to the discussion of such a technic that this paper will be largely confined.

Spinal anesthetic solutions are considered as: (1) hypobaric if they are lighter than spinal fluid; (2) isobaric if their specific gravity is approximately the same as that of spinal fluid, and (3) hyperbaric if their specific gravity is greater than that of spinal fluid.

It is important that the anesthesiologist know in advance the relationship of the specific gravity of the anesthetic solution to that of the spinal fluid. It is obvious that when the solution is heavier than spinal fluid it will tend to flow downward and, therefore, if the patient is in the head down or Trendelenburg position during the early period following the injection of the agent, it will flow cephalad. Conversely, with the patient in the head up or Fowler position, it will have a tendency to flow caudad. If the solution is lighter than spinal fluid, the reverse will be true, that is, the anesthetic solution will tend to travel in an upward direction. Hence, if it is desirable to confine the anesthesia to the lower part of the body, the patient should be in the head down position during the early period following the injection if a hypobaric solution is used. When the solution is isobaric, that is, approaching the specific gravity of spinal fluid, it tends to spread in both the cephalad and caudad directions at about an equal rate regardless of the position in which the patient is tilted. It is much more difficult to control the height of spinal anesthesia with an isobaric solution than it is with either hypobaric or hyperbaric solutions. As a rule, anesthesia tends to develop much more slowly with isobaric than with either hyperbaric or hypobaric solutions. Since there is considerable variation in the specific gravity of spinal fluid (1.001 to 1.009) a solution whose specific gravity is within this range may bear a different relationship to the spinal fluid from that anticipated. For this reason it is sometimes difficult to predict the height of spinal anesthesia with isobaric solutions. In our experience it is somewhat easier to control the height of spinal anesthesia with hyperbaric solutions than it is with hypobaric solutions.

The rate of injection is an important factor in determining the level of spinal anesthesia. In general, a rapid injection results in a higher level of spinal anesthesia. If the injection is made slowly with an isobaric solution, regardless of the position of the patient, the greatest concentration of the agent will be at the site of injection With a hyperbaric or a hypobaric solution this is true only when the patient is level. The statement that a slow injection will result in maximal concentration at the lower levels or near the site of injection requires some qualification. With a hyperbaric solution, when there is considerable difference between the specific gravities of the spinal fluid and the solution injected,

as with spinal anesthetic agents to which a considerable amount of dextrose has been added, a slow injection with the patient in the head down position may produce anesthesia much higher than a rapid injection. This is due to the fact that the heavier, somewhat syrupy solution trickles out of the end of the needle and runs down in the subarachnoid space as a mass without much mixing with the spinal fluid.

The volume of spinal anesthetic solution injected is also important in determining the level of anesthesia. The greater the volume of solution with a given amount of drug, the higher the level of anesthesia. Obviously, with a large volume of low concentration, the anesthesia may be quite high but not so intense, and the duration considerably less.

Barbotage is a factor which plays a considerable part in the height of spinal anesthesia. Barbotage may be defined as the mixing of the anesthetic solution with the spinal fluid as it is injected. Part of the agent is injected, followed by withdrawal of some spinal fluid, and the process repeated several times.

If a large amount of spinal fluid is withdrawn prior to the injection of the anesthetic agent, the level of anesthesia will be higher. This may be due to a lowering of the spinal fluid pressure as well as to the diminishing of the volume of fluid into which the agent is injected.

Temperature plays a part in the height of spinal anesthesia. If a solution is warmer than spinal fluid when it is injected, it tends to spread more rapidly and thus produce higher levels of anesthesia earlier than with a colder solution.

The site of injection is a factor in determining the height of spinal anesthesia. If the injection is made in the lumbar area, however, the interspace employed is of minor importance. The truth of this statement becomes evident when we reconsider the distances that the agent must travel in the subarachnoid space, particularly for anesthesia for upper abdominal surgery. Often, too much emphasis is placed on the site of injection to the neglect of other more important factors.

Anesthetic Solution

This discussion will be limited to the technic commonly employed at the Lahey Clinic for spinal anesthesia. For many years tetracaine (pontocaine) has been the agent of choice for spinal anesthesia Pontocaine is approximately ten times the strength of procaine gram for gram, and in comparable anesthetic doses, that is, with a dose of pontocaine weighing one-tenth that of procaine, anesthesia will last approximately twice as long. Pontocaine is marketed in crystalline form (niphanoid) or as a 1 per cent solution in normal saline, in ampules containing 20 mg. of the drug. The specific gravity of a 1 per cent solution of pontocaine in normal saline is approximately 1.0069 This is very close to the average for spinal fluid which ranges from 1.001 to 1.009. Pontocaine in the 1 per cent solution or as niphanoid dissolved in saline solution or spinal fluid, for all practical purposes, may be considered isobaric and movement will, of course, be equal in both directions from the site of injection irrespective of the position in which the patient is lying. Obviously, the greatest concentration will be at the site of injection. If, however, the solution is modified by the addition of an innocuous substance with a fairly high specific gravity as compared with

that of spinal fluid, an anesthetic solution is obtained that is heavy enough to allow the agent to be carried cephalad by gravity more or less as a mass. Ten per cent dextrose with a specific gravity of 1.039 is a satisfactory substance for this purpose.

The determination of dosage for spinal anesthesia in adults is shown in Table 1.

*Table 1. Determination of Dosage of Pontocaine for Spinal Anesthesia in Adults**

	PONTOCAINE MG.	10 PER CENT DEXTROSE CC.	POSITION FOR INJECTION	HEAD POSITION
Upper abdomen	12–16	1.8–2.4	10 degree Trendelenberg	Elevated
Lower abdomen	10–14	1.5–2.1	10 degree Trendelenberg	Elevated
Perineum and lower extremities................	8–10	0.8–1.0 (1 cc. of spinal fluid)	Level	Elevated

* A solution of 0.3 per cent pontocaine in 6 per cent dextrose is now available in 5 cc. ampules. Each cubic centimeter of this mixture contains 3 mg. of pontocaine. This mixture has greatly simplified the technic of spinal anesthesia with pontocaine. The pontocaine concentration in this ready prepared mixture is only 75 per cent of that in the mixtures listed in Table 1 on dosages. If the same volumes are employed as recommended in this table, the total dose of pontocaine will be only three-fourths that previously used. In most instances this reduced dosage will be adequate. The dosage range with this mixture is as follows: abdomen, 9 to 12 mg. (3 to 4 cc.), perineum and extremities, 6 to 9 mg. (2 to 3 cc.).

Technic

When anesthesia is desired to the fourth thoracic segment, the technic is as follows: The patient is turned to the lateral decubitus position and the head is elevated by means of an adjustable bar (sandbags may be used for this purpose, also). This is to prevent the agent from progressing cephalad into the upper thoracic and cervical portions of the subarachnoid space. This bar also catches the lower shoulder of the patient, preventing him from sliding when the head of the table is lowered. The previously estimated dose of pontocaine is drawn into a 5 cc. syringe to which is added 10 per cent dextrose in a volume equivalent to one and one-half times that of the 1 per cent pontocaine. This solution is then thoroughly mixed After the spinal puncture, the patient is placed in 10 degree Trendelenburg position, with the head elevated, and the 5 cc. syringe containing the anesthetic mixture is connected to the needle. The plunger is withdrawn slightly to make certain that the point of the needle is in the dural sac. The injection is made at the rate of about 0.25 cc. per second, after which the patient is turned supine and the level of anesthesia immediately checked. Notice of the time is made when the injection is started, since under no circumstances should the patient be left in the Trendelenburg position longer than one minute from the start of the injection without the height of anesthesia being checked. After the lapse of one minute after beginning the injection the table should be leveled. At this time the upper border of anesthesia will usually be to the sixth or seventh thoracic segment and will proceed up to the fourth

or fifth segment in another one or two minutes. Should this not be the case, the table may again be changed to a 10 degree Trendelenburg position until the desired height is obtained. During all of these procedures care should be taken to see that the head is well elevated so that a marked upward slant of the cervical and upper thoracic portion of the spinal cord is maintained. Careful attention must be paid to the cephalad progress of the anesthesia; an undesirable height may occasionally be obtained in less than one minute. Should this happen, the table is immediately tilted to a 5 degree Fowler position to prevent further cephalad flow of the anesthetic mixture. While this will not immediately lower

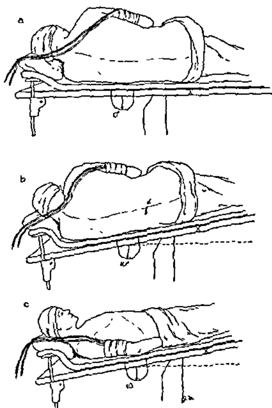


Fig 463. Position for spinal anesthesia employing hyperbaric solution (pontocaine-dextrose). *a*, Position for spinal puncture. *b*, Position for injection of anesthetic solution *c*, Position for obtaining height of anesthesia.

the height of anesthesia, it will lessen its intensity and shorten its duration at the upper border. The respirations and blood pressure should be carefully watched during this early period in order that the anesthesiologist may be forewarned of any untoward reaction.

For operations for which steep Trendelenburg position is desired immediately, the technic is modified as follows: after one minute in 10 degree Trendelenburg position, the table is turned to 5 degree Fowler position for at least two minutes Following this maneuver the patient may immediately be placed in the Trendelenburg position. Careful watch should be maintained for any degree of intercostal paralysis (Figs. 463, 464 and 465).

For lumbar operations such as nephrectomy or nephrostomy, the side to be operated on is placed down when the injection is made, on the theory that the

greater anesthsia will be on the dependent side since the anesthetic solution is heavier than spinal fluid.

For inguinal operations such as herniorrhaphy, the injection may be made with the patient level or in only slight Trendelenburg position for one minute.

A satisfactory technic for operations on the lower extremities, perineum, rectum, prostate or bladder is as follows. The spinal puncture is made in the fourth lumbar interspace. The solution consists of 1 cc. (10 mg.) of 1 per cent pontocaine and 1 cc. of 10 per cent dextrose to which is added 1 cc. of spinal fluid withdrawn after the syringe has been connected to the needle in the subarachnoid space. The injection is made at about 0.5 cc. per second with the table level and the patient's head elevated. Following the injection, the patient is placed on his back for two or three minutes and anesthesia tested. With this technic anesthesia is usually confined to below the twelfth thoracic segment, which is satisfactory for operations on the anus, rectum or lower urinary tract. The patient may safely be turned on his abdomen or placed in the lithotomy position immediately after the proper height of anesthesia has developed.

Various changes in these details may be made if desired. When using a hyperbaric solution for spinal anesthesia, however, care must always be taken to see that the head is kept well elevated and the patient is not left too long in a downward slant.

The dose of an anesthetic agent in any given case is a matter of judgment. Table 1 for dosage of pontocaine, expressed in milligrams for adults, has proved valuable. These doses are meant as suggestions and should be considered starting points for the anesthesiologist's judgment.

CONTINUOUS SPINAL ANESTHESIA

The introduction of the continuous technic for spinal anesthesia by Lemmon has greatly widened the field of usefulness of this method of anesthesia. Not only has this technic eliminated one of the greatest objections to spinal anesthesia, namely that the operation frequently outlasted the anesthesia necessitating the use of supplementary agents and methods which were often much less satisfactory, but it has enabled us to tailor the anesthetic dose to the surgical requirements more accurately. In fact, this technic has been almost as useful in permitting us to use very small doses of anesthetics for short procedures as it has in enabling us to use larger doses over a longer period of time for the more extensive procedures.

In addition to the materials required for ordinary spinal anesthesia, continuous spinal anesthesia requires special needles made of malleable metal to allow for considerable bending without danger of breaking. Furthermore, a rubber covered mattress, 5 inches thick, 18 inches wide and 6 feet long, with a cut out part 7 inches in length which comes under the lumbar area when the patient is supine, is desirable. The mattress is divided in half so that the portion which supports the lower extremities may be detached for perineal operations. In addition, it is necessary to have approximately 30 inches of fine caliber rubber tubing with Luer-Lok connection at each end for attaching the spinal needle and the syringe containing the spinal anesthetic solution (Figs. 464 and 465).

Technic

While there are many variations of the original continuous spinal technic as described by Lemmon, this discussion will be confined to only one technic,

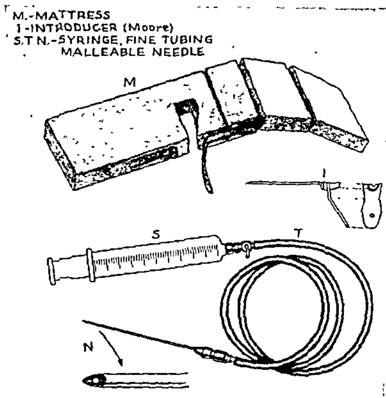


Fig. 464. Extra equipment for continuous spinal anesthesia (Lemmon).

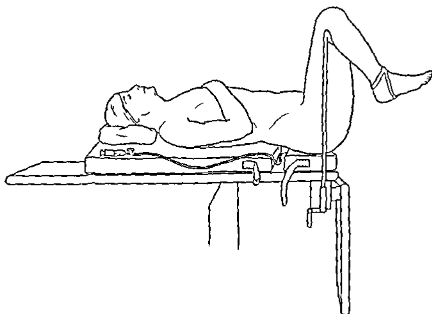


Fig. 465. Position of patient on mattress for perineal operation under continuous spinal anesthesia Note needle in place and lower part of mattress removed.

employing pontocaine and dextrose. It is the technic that has been employed at this clinic for several years.

Spinal puncture with the malleable needles used for continuous spinal anesthesia is greatly facilitated by the use of a special introducer (Moore). This type of introducer is so designed that it can be removed after the needle is in place without dislodging the needle. The reservoir of spinal anesthetic solution for continuous spinal anesthesia is prepared as follows: 3 cc. of 1 per cent pontocaine, 6 cc. of 10 per cent dextrose and 1 cc. of normal saline are drawn into a 10 cc. syringe and thoroughly mixed. This makes a total volume of 10 cc. and

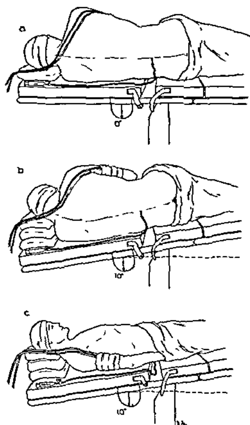


Fig. 466. Position for induction of continuous spinal anesthesia (Lemmon). *a*, Patient in left lateral decubitus position, spinal needle in place and syringe and tubing connected. *b*, Position of patient for injection of hypobaric solution (pontocaine-dextrose mixture) for continuous spinal anesthesia. *c*, Position of patient for obtaining height of spinal anesthesia by continuous method.

is a 0.3 per cent solution of pontocaine. Each cubic centimeter of the mixture contains 3 mg of pontocaine. The tubing is filled with the mixture before it is attached to the spinal needle. The initial dose, 9 to 15 mg. (3 to 5 cc.) is injected slowly (0.25 cc. per second) into the third lumbar interspace while the patient is still lying on his side. Prior to starting the injection the table is turned to the head down position, 10 degrees from the horizontal, with the patient's head elevated to raise the cervical and upper thoracic spine. Immediately following the injection the patient is turned on his back and the height of anesthesia should be tested almost constantly until the desired level is obtained. The level of anesthesia usually will be to the nipple line (fourth thoracic segment) in one to two minutes. The patient should not be left in the head down position longer than one minute unless tests show the anesthetic level to be lower than the xiphoid process (sixth thoracic segment). An ac

mination of the height of anesthesia should be obtained repeatedly as long as the patient is in the head down position and for several minutes thereafter (Fig. 466).

When pontocaine is the anesthetic drug used it is rarely necessary to administer secondary doses of the anesthetic mixture more frequently than every one and one-half hours.

The technic for subsequent doses of pontocaine-dextrose for spinal anesthesia by the continuous method is as follows: at the end of one hour the stopcock on the Luer-Lok connection to the syringe is opened and the spinal fluid is withdrawn in an amount sufficient to equal one-half that remaining in the syringe and tubing after the initial injection. The anesthetic mixture will now contain 2 mg. of pontocaine per cubic centimeter instead of the original 3 mg. At the end of one and one-half hours or when there is evidence that the initial dose is wearing off, a subsequent dose is administered by the following technics. If the patient is level the second dose should be approximately one-half the original dose. It is given in the following manner. 0.5 cc. of spinal fluid is withdrawn into the tube and 1 cc. of the mixture is injected. This process is repeated until the desired dose has been administered. If the patient is in Trendelenburg position, the second dose should not exceed one-fourth to one-third the original dose and should be administered slowly without barbotage.

A notable modification of Lemmon's technic for continuous spinal anesthesia is that made by Tuohy. By this technic a number 3½ ureteral catheter is inserted into the subarachnoid space through a 16 gauge Huber needle, which is withdrawn, leaving the catheter in place. The catheter can be directed either cephalad or caudad by the position of the opening in the end of the Huber needle. This technic has the advantage of obviating the need for a special mattress and is particularly useful in operations for which the patient is not on his back.

Saklad has further modified the technic for continuous spinal anesthesia. He passes the number 3½ ureteral catheter cephalad into the subarachnoid space until the tip lies opposite or near the nerve roots supplying the area where the maximum intensity of the anesthesia is desired. For upper abdominal surgery this would mean that the catheter should be advanced cephalad in the subarachnoid space for 20 to 25 cm. When low concentration of the anesthetic solution (0.05 to 0.1 per cent pontocaine or 0.5 to 1.0 per cent procaine) is used it is possible to obtain spinal anesthesia with a surprisingly small total dosage of the drug. Satisfactory anesthesia for upper abdominal surgery has been obtained by this method with as little as 2 to 3 mg. of pontocaine. With this technic anesthesia is usually segmental in distribution and may be confined almost entirely to the abdomen with little if any anesthesia in the lower extremities.

THE MANAGEMENT OF THE PATIENT UNDER SPINAL ANESTHESIA

The management and supervision of the patient under spinal anesthesia is extremely important. No spinal anesthesia is finished upon completion of the spinal puncture and injection of the anesthetic agent. The patient should be under the constant care and observation of a physician acquainted with all the possible complications of spinal anesthesia and he should have adequate facilities to control or correct any untoward condition which may arise.

Many of the difficulties encountered during the course of the spinal anesthesia are associated with improper distribution of the spinal anesthetic agent in the subarachnoid space. The anesthetic agent may not reach a level sufficiently high to produce adequate anesthesia for muscular relaxation and to eliminate all painful stimuli. Sometimes pain from the operative site may be referred to an area not under the control of the spinal anesthetic agent and thus be a source of physical distress to the patient. When such a situation arises, a supplementary form of anesthesia must be used. Pentothal sodium intravenously or cyclopropane gas is usually quite satisfactory as a supplementary agent.

With a single dose of spinal anesthetic agent, too often the operation outlasts the anesthesia. This condition, of course, necessitates the use of supplementary general anesthesia. The transition is more easily accomplished if the supplementary agent is started before the patient begins to feel pain or there is any loss of muscular relaxation. Warning signs, other than the elapse of time, that the anesthesia may be about to wear off are increased restlessness, sweating, rise in blood pressure, or the patient may complain of a vague feeling of discomfort, without any actual pain, at the site of the operation.

The intravenous administration of curare has proved to be of great value as an adjuvant to inadequate spinal anesthesia when muscular relaxation is desired. This drug, of course, is not an anesthetic and is used in combination with other supplementary agents, such as cyclopropane or pentothal sodium.

Respiratory Impairment

Serious impairment of respiration may be a complication of spinal anesthesia. This is particularly true if this form of anesthesia is employed for upper abdominal surgery. It is of utmost importance that respiratory impairment should be recognized immediately. If the motor divisions of the thoracic nerves are anesthetized as high as the fourth thoracic segment (the height necessary for satisfactory upper abdominal surgery), the intercostal muscles below this level will be inactive, and the elevation of the ribs and expansion of the chest on inspiration will be brought about by the pull of the four upper intercostal muscles. If the agent continues to progress cephalad, the remaining intercostal muscles become inactive and the chest no longer expands with inspiration. If the patient is asked to take a deep breath at this time, only diaphragmatic breathing can be observed. The chest will remain entirely motionless or the intercostal spaces may even retract on inspiration. This is one of the earliest and most important warning signs that the anesthesia is going too high. At this time the patient may also complain of numbness or tingling in the hands. This is, of course, due to involvement of the roots of the brachial plexus. If the agent continues until it reaches the level of the fourth cervical nerve root, the diaphragm becomes paralyzed and complete respiratory arrest follows. Usually, before respiration becomes completely arrested the conscious patient will attempt to increase the size of the chest cavity by using the accessory muscles of respiration. This can be detected by observing the patient's neck for increased activity of the sternomastoid and platysma muscles. The patient may also lose his voice and become quite apprehensive (Fig. 467).

If unrelieved, this condition will lead to anoxia, circulatory collapse and death.

The treatment is obvious. It consists of the administration of oxygen with some mechanical assistance to inspiration if there is inadequate respiratory exchange. This assistance is absolutely essential if there is complete respiratory arrest. It can best be accomplished by administering oxygen from a gas machine and exerting rhythmic pressure on the rubber breathing bag coincidental with each attempt at inspiration on the part of the patient. If there is no attempt at inspiration, the lungs should be inflated by pressure on the breathing bag at a rate of about sixteen times a minute. Obviously, the establishment of a free and unobstructed airway is imperative. Respiratory stimulants are not indicated and pressor drugs should be used at this stage only if indicated because of secondary

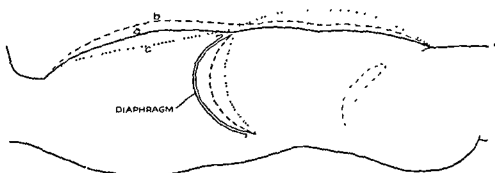


Fig. 467. Position of chest and abdomen under spinal anesthesia. *a*, Normal position at end of expiration. *b*, Position at end of normal inspiration. *c*, Position at end of inspiration, with complete intercostal paralysis.

circulatory depression. If immediate and adequate treatment is instituted, this condition need cause no great alarm and usually secondary circulatory depression does not occur. A period of respiratory depression rarely lasts longer than twenty or thirty minutes On the other hand, without immediate and adequate treatment, this complication will result in a fatality.

Circulatory Depressions

Rather profound circulatory depression may accompany spinal anesthesia. Circulatory depression is much more common with high spinal anesthesia than when the anesthesia is confined to the lower part of the abdomen. This depression may be further enhanced by surgical manipulation in the abdomen. Circulatory depression will surely follow unrelieved respiratory depression. The routine use of a pressor drug (50 to 75 mg. of ephedrine or 20 mg. of desoxyephedrine) intramuscularly a few minutes before the induction of spinal anesthesia is a valuable safeguard against circulatory depression.

Many pressor drugs have been employed successfully to combat blood pressure falls which occur in spite of prophylactic intramuscular administration of ephedrine or desoxyephedrine. Epinephrine is an effective blood-pressure raising drug. This drug, however, is rather transient in effect and may seriously disturb cardiac rhythm. Furthermore, there may be a compensatory fall in blood pressure following the transient rise. Ephedrine given intramuscularly is usually effective but it is quite slow in action and it is for this reason that if this agent is used alone to treat a serious fall in blood pressure, 0.25 to 0.5 cc. should be given intravenously. An extract of the posterior pituitary gland (pitressin) is effective in raising

blood pressure and is usually quite prompt in action. The fact that this drug may constrict the coronary arteries and the danger of a decrease in blood supply to the heart must be borne in mind. The danger may, perhaps, be minimized if the pitressin is combined with ephedrine. A combination of 5 units of pitressin (0.25 cc.) and 25 mg. of ephedrine (0.5 cc.) intramuscularly has proved satisfactory for the treatment of blood pressure falls due to spinal anesthesia. The response is usually prompt and well sustained. One-fourth to one-third of this dose may be given intravenously in the presence of a severe fall in blood pressure. The heart rate and rhythm usually are changed very little, if any, with

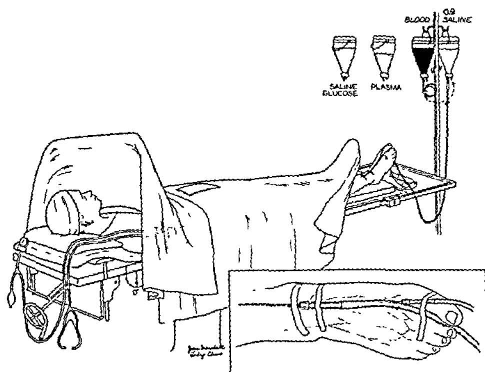


Fig. 468. Patient ready for operation under spinal anesthesia. Note blood pressure cuff in place and constant intravenous drip with needle in saphenous vein. Supportive fluid and supplementary intravenous agents available.

this combination. Neosynephrin is an effective drug for raising the blood pressure. In single doses, however, it is quite transient in its action. It usually does not disturb cardiac rhythm although it may slow the pulse considerably. A continuous drip of a very dilute solution of neosynephrin (0.5 cc. or 5 mg.) in 500 cc. of normal saline solution is effective as a means of maintaining blood pressure under spinal anesthesia. This method allows for very fine control and permits rapid administration in the event of an acute fall in blood pressure. It must always be borne in mind when using pressor drugs that they must never be substituted for fluid and blood in the presence of shock resulting from blood loss of trauma.

Nausea, retching and vomiting are frequent, annoying complications of spinal anesthesia. If these complications are more than a momentary disturbance, the patient should be made unconscious by the use of a supplementary agent such as cyclopropane or pentothal sodium. This enables the surgeon to continue the operative procedure without interruption and relieves the patient of an un-

comfortable and disturbing experience. The danger of vomitus being aspirated into the trachea should always be kept in mind when a general anesthetic agent is administered for the relief of nausea and vomiting.

There is no reason why any patient who objects to being awake during an operation cannot have the comfort of being asleep and at the same time have the advantages of spinal anesthesia. Frequently, an additional dose of morphine intravenously and the intravenous administration of 1 to 3 grains of nembutal after the patient is in the operating room will allay apprehension and nervousness.

If an intravenous needle is placed in the great saphenous vein near the medial malleolus and a slow drip of fluid maintained throughout an operative procedure, a route is immediately available for the administration of supplementary anesthetic agents or for the administration of supportive drugs and fluid. The use of the saphenous vein has the advantage of removing the intravenous apparatus to a point where it will not interfere with any type of surgery except that on the lower extremities. If the intravenous drip is not started until after the spinal anesthetic is given, the patient will have no discomfort from the insertion of the needle, and the dilatation of the veins which follows spinal anesthesia facilitates its insertion (Fig. 468).

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COMPLICATIONS OF SPINAL ANESTHESIA

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It is perhaps unfortunate that the actual induction of spinal anesthesia is usually such a relatively simple procedure. This has too often led to a lack of appreciation of its magnitude as well as the hazards with which it may be accompanied. The management and supervision of the patient under spinal anesthesia is extremely important. No spinal anesthesia is finished upon completion of the spinal puncture and injection of the anesthetic agent. The patient should be under the constant care and observation of a physician acquainted with all the possible complications of spinal anesthesia and who has adequate facilities to prevent or correct any untoward conditions that may arise.

For the sake of convenience, complications of spinal anesthesia may be divided into: (1) those occurring at the time of operation and (2) those that do not manifest themselves until the postoperative period.

COMPLICATIONS OCCURRING AT THE TIME OF OPERATION

Undoubtedly a very large majority of complications encountered during the course of spinal anesthesia are associated either directly or indirectly with improper distribution of the anesthetic agent in the subarachnoid space. The agent may not reach a level sufficiently high in the subarachnoid space or may travel too far cephalad, thus reaching a level too high.

Inadequate Anesthesia. If the level is not high enough to provide adequate muscular relaxation and to eliminate painful stimuli, the spinal anesthesia must, of necessity, be considered inadequate and a supplementary agent used. Pentothal sodium intravenously or cyclopropane gas is usually quite satisfactory as a supplementary agent for the relief of pain. Curare and curare-like drugs, administered intravenously, have proved to be of great value as adjuncts to inadequate spinal anesthesia when muscular relaxation is desired.

Wearing Off of Anesthesia before Completion of Operation. With a single dose of a spinal anesthetic too often the operation outlasts the anesthesia. This condition, of course, necessitates the use of supplementary anesthesia. As with inadequate spinal anesthesia, pentothal sodium or cyclopropane has proved quite useful as a supplementary agent with the addition of curare for muscular relaxation. The transition is more easily accomplished if the supplementary anesthetic is started before the patient begins to feel pain or there is any loss of muscular relaxation Warning signs other than the elapse of time or tight abdominal muscles that the anesthesia may be about to wear off are: increased restlessness, sweating, rise in blood pressure or the patient may complain of a vague feeling of discomfort, without any actual pain, at the site of the operation.

Revision of article originally published in Surgical Clinics of North America, 30:693–703 (June) 1950.

Respiratory Depression. If the spinal anesthetic agent is distributed too far cephalad in the subarachnoid space, serious respiratory depression may result. This complication is more prone to occur when spinal anesthesia is employed for upper abdominal surgery. If the motor divisions of the thoracic nerves are anesthetized as high as the fourth thoracic segment (the height necessary for satisfactory upper abdominal surgery), the intercostal muscles below this level will be inactive and the elevation of the ribs and expansion of the chest with inspiration will be the result of the pull of the four upper intercostal muscles. If the agent continues to progress cephalad until the remaining intercostal nerves become involved, the chest will no longer expand with inspiration. If the patient is asked to take a deep breath at this time, only diaphragmatic breathing can be observed. The chest will remain entirely motionless or the intercostal spaces may even retract on inspiration. This is one of the earliest and most important *warning signs that anesthesia is going too high. At this time the patient may* complain of numbness or tingling in the hands due to involvement of the roots of the brachial plexus. If the agent continues cephalad until it involves the motor roots of the fourth cervical nerves, the diaphragm becomes paralyzed and complete respiratory arrest ensues. Usually before respiration becomes completely arrested the conscious patient will attempt to increase the size of the chest cavity on inspiration by greater effort on the part of the accessory muscles of respiration. This can be detected by observing the patient's neck for increased activity of the sternomastoid and platysma muscles. The voice may be lost and the patient becomes quite apprehensive.

It is of utmost importance that respiratory impairment be recognized at once. If unrelieved, this condition will lead to anoxia, circulatory collapse and death. The treatment is obvious. It consists of the administration of oxygen, with some mechanical assistance to inspiration if there is inadequate respiratory exchange. This assistance is absolutely essential if there is complete respiratory arrest. Assistance to respiration is best accomplished by administering oxygen from a gas *machine and exerting rhythmic pressure on the breathing bag coincident* with each attempt at inspiration on the part of the patient. If there is no attempt at inspiration, the lungs should be inflated by pressure on the breathing bag at a rate of about sixteen times per minute. Obviously, the establishment of a free and unobstructed airway is imperative. This may require the insertion of an endotracheal tube. Respiratory stimulants are not indicated and pressor drugs should be used at this stage only to treat secondary circulatory depression. If immediate and adequate treatment is instituted, this condition need cause no great alarm and usually secondary circulatory depression does not occur. Respiratory depression due to spinal anesthesia rarely lasts longer than twenty or thirty minutes. While this respiratory depression is usually thought of as peripheral in nature, it is quite possible that the anesthetic agent may be present in the fourth ventricle and exert an influence directly on the respiratory center.

Circulatory Depression. Some degree of circulatory depression quite commonly accompanies spinal anesthesia. This depression may at times be profound and alarming *Serious falls of blood pressure are much more* common with high spinal anesthesia than when the anesthesia is confined to the lower part of the abdomen. It has been suggested that this fall in blood pressure was

due to an hematogenous intoxication and that the rapid absorption into the blood stream of the anesthetic drug injected in the subarachnoid space produced the hypotensive effects observed. However, we know that much larger quantities of the agent can be injected directly into the blood stream without producing hypotension comparable to that produced by spinal anesthesia. Smith and his associates[3] have suggested that the hypotension is due largely to a stagnation of the blood in the postarteriolar bed. They have postulated that this venous stagnation is accompanied by a lessened stroke volume and a decreased cardiac output. Perhaps the theory at the present time which has the widest acceptance is that of paralysis of the vasoconstrictor fibers in the anterior spinal nerve roots with a resulting loss of tone and stagnation of the blood in the arteriolar bed. This pooling of blood in the arteriolar bed is followed by a decreased cardiac output and a lowered systolic blood pressure.

The hypotension which so often accompanies spinal anesthesia may be alarming and should always be considered unphysiologic. Surgical manipulation in the abdomen, of course, plays a part in the production of blood pressure falls, and circulatory depression will most surely follow unrelieved respiratory depression.

It has been well demonstrated that the routine use of sympathomimetic drugs prior to the administration of a spinal anesthetic is a valuable safeguard against circulatory depression. For many years 50 to 75 mg. of ephedrine has been almost uniformly accepted as the routine preanesthetic drug for the support of blood pressure.

Many drugs have been used to treat a falling blood pressure under spinal anesthesia, notably epinephrine, ephedrine and neosynephrine. Epinephrine is evanescent in its action, however, it has the greatest effect of any agent. The systolic rise may be accompanied by a diastolic fall. It does not stimulate the respiratory center as does ephedrine. Occasionally apnea may follow the use of epinephrine due to the sudden increase of pressure in the carotid sinus and the cardio-aortic area. Increased pulse rate frequently accompanies the use of this drug, and it may be followed by bradycardia. The hypertension also may be followed by hypotension. Restlessness and apprehension are often distressing side effects of epinephrine. This drug acts by direct stimulation on the myocardium and the conduction tissue, and, of course, is dangerous in the presence of other factors affecting cardiac irritability. Repeated doses of epinephrine cause equal action.

Ephedrine lasts longer but does not produce as marked an effect as epinephrine, and is not usually followed by the hypotension so often observed after administration of epinephrine. However, repeated doses will not produce an equal effect and may cause cardiac depression. Ephedrine is a respiratory stimulant and may increase the minute volume as much as 20 per cent. Bradycardia may be an accompaniment and some central side effects, such as nervousness, may be noted.

Neosynephrine produces a greater effect than ephedrine and does not last as long. It does, however, last approximately five times as long as epinephrine. Its action is largely that of vasoconstriction but there may be some direct cardiac action. Arrhythmias following the use of neosynephrine are

ever, bradycardia may be an accompaniment. This is probably due to direct action on the sino-auricular node or it may be a compensatory reflex. The heart has a tendency to dilate when neosynephrine is used. There is no central stimulation. Ten to 20 mg. of neosynephrine in 1000 cc. of solution (physiologic salt or 5 per cent dextrose) as an intravenous drip has proved to be of great value in supporting blood pressure during spinal anesthesia. The intravenous administration of neosynephrine affords better minute to minute control of blood pressure. One must always bear in mind that a pressor drug should never be used as a substitute for fluids or blood in cases of hypotension due to blood loss or surgical shock.

Nausea, Retching and Vomiting. Nausea, retching and vomiting are common and annoying complications of spinal anesthesia. With the increasing tendency to give some sort of a complementary agent to render the patient unconscious during the course of spinal anesthesia, we do not see these complications as frequently as formerly. However, when spinal anesthesia is employed without a complimentary or supplementary agent, and nausea and retching are more than a temporary disturbance, the patient should be rendered unconscious with some general anesthetic agent such as cyclopropane or pentothal. This enables the surgical procedure to continue uninterruptedly and relieves the patient of an uncomfortable and disturbing experience. The danger of vomitus being aspirated into the trachea and bronchi should always be borne in mind. This danger may be further enhanced if a general anesthetic is administered after the patient has already vomited.

Pyloric or Small Bowel Obstruction. Another alarming complication may arise with patients who have obstruction of the pylorus or small bowel with proximal dilatation of the intestine. The administration of a spinal anesthetic with its tendency to increase the tone of the bowel followed by manipulations of the bowel by the surgeon may result in pouring out of large quantities of material into the pharynx from where it may be aspirated into the respiratory passages. Unless prompt, adequate treatment is instituted at once this complication may be serious. The patient should immediately be placed in the head-down position and all of the material aspirated from the pharynx. If there is evidence that any of the material has been aspirated into the trachea or bronchi, bronchoscopy should be performed immediately to clear the air passages. As a precautionary measure against this complication, the stomach should be thoroughly evacuated by means of a Levin tube prior to the administration of the anesthetic. The Levin tube should be left in place so that any material that may later accumulate can be aspirated. The presence of a Miller-Abbott tube in the small bowel is not a sufficient safeguard against the aspiration of vomitus, and if there is any question of an obstruction still persisting at the time of operation, a Levin tube should be placed in the stomach in addition to the Miller-Abbott tube. Neglect of this precautionary measure may result in a fatality.

Nervousness and Apprehension. Many patients object to being awake during an operation. There is no reason why any patient who wishes it cannot be asleep and still have the advantage of spinal anesthesia. An additional dose of morphine intravenously after the patient is in the operating room and before the induction of spinal anesthesia often allays apprehension and nervousness.

The intravenous administration of 1 to 3 grains of pentobarbital sodium (nembutal) is valuable also for patients who are nervous or apprehensive. Intravenous pentobarbital sodium is less likely to cause nausea than is intravenous morphine. Quite often an intravenous dose of morphine or nembutal is all the supplementary anesthetic needed.

Provision of an Intravenous Route for Supplementary Agents. If an intravenous needle is placed in the great saphenous vein near the medial malleolus and a small drip of fluid maintained throughout an operative procedure, a route is constantly available for the administration of supplementary anesthetic agents or for the administration of supportive drugs and fluids. The use of the saphenous vein has the advantage of removing the intravenous apparatus to a point where it will not interfere with any type of surgery except that on the lower extremities. If the intravenous drip is not started until after the spinal anesthetic is given the insertion of the needle causes no discomfort and the dilatation of the vein which follows spinal anesthesia facilitates the insertion of the needle. In the past this procedure was reserved for poor risk patients or for patients upon whom extensive operative procedures were contemplated. More recently it has become almost a routine with spinal anesthesia and the feeling of security that comes with having an intravenous route always available for the administration of drugs and fluids is well worth the additional effort and expense which this procedure entails.

NEUROLOGIC COMPLICATIONS OF SPINAL ANESTHESIA

Since the central nervous system is the site of action of all anesthetic agents whether general or spinal, it is not surprising that complications of the nervous system occur after all types of anesthesia. While no particular type of neurologic complication can be said to be limited entirely to one type of anesthesia, and hemiplegias and various types of peripheral nerve lesions can follow both general and spinal anesthesia, certain complications are much more prone to follow spinal anesthesia and certain others more prone to follow general anesthesia. Convulsions, extrapyramidal rigidity, postoperative psychoses and degenerative changes in the cerebral cortex and lenticular nuclei have been reported most often after general anesthesia. Headaches, septic and aseptic meningitis, arachnoiditis, neuritis, myelitis and the so-called cauda equina syndrome comprise the complications most frequently reported following spinal anesthesia.

Etiology. It is usually quite difficult to determine the exact etiologic factor responsible for neurologic complications following spinal anesthesia. Certain spinal anesthetic drugs in high enough concentration cause a specific, toxic, destructive effect on nerve tissue when injected into the subarachnoid space in experimental animals. The incidence of these lesions increases as the concentration of the drug is increased. Also, it seems evident that the lesions produced are the result of the spinal anesthetic agent itself since the damage is usually manifested so soon after the administration of the drug. Other possible etiologic factors must, however, be considered.

Direct Trauma. Direct trauma may play a part in some neurologic complications following spinal anesthesia. There does seem to be a definite relationship between a traumatic spinal puncture which causes pain to extend down

one leg followed by the injection of a spinal anesthetic drug with a persistent neurologic complication referable to the same leg, yet in view of the large number reported of diagnostic spinal punctures performed without serious neurologic complications, it seems unlikely that trauma can be considered as a major etiologic factor in the production of postspinal neurologic complications.

Inflammatory Reaction. The rapidity of onset of most of these complications of itself seems to preclude inflammatory reaction as an etiologic factor. Furthermore, it is usually impossible to cultivate organisms from the spinal fluid of patients with postspinal neurologic complications, and the predominating cells are generally lymphocytes rather than polymorphonuclear leukocytes. These complications are seldom associated with an elevation in temperature or other signs of an inflammatory process.

Toxicity of the Drug. There is considerable evidence that neurologic complications are due to direct toxic action of the agent itself. Not all of the nerves influenced by the anesthetic agent are affected by the paralysis. The anesthetic may have been sufficient for an upper abdominal operation, yet the ultimate paralysis be limited to the lumbosacral or sacral nerves. These, of course, are the nerves that are exposed to the greatest concentration of the agent. Permanent paralysis seems to occur most frequently in the nerve tissue which comes in contact with the drug in its greatest concentration. Furthermore, it seems unlikely that these complications are of an allergic nature, but that the concentration employed with most anesthetic drugs is only a little short of that which would produce paralysis in a higher percentage of patients.

Neurologic Disease Precipitated by Spinal Anesthesia. Spinal anesthesia may be a precipitating factor in the exacerbation of certain preexisting neurologic conditions such as pernicious anemia with combined sclerosis, multiple sclerosis and tabes dorsalis Two patients at the Lahey Clinic received spinal anesthesia for the removal of carcinomas in other parts of the body and, upon examination, because of the fact that the spinal anesthesia failed to wear off, were found to have metastasis to the spine resulting in almost complete cerebrospinal fluid block.

In addition to the group of peripheral neuropathies commonly referred to as the cauda equina syndrome, such other complications as headaches, septic and aseptic meningitis, arachnoiditis and cranial nerve palsies must be considered as neurologic complications.

Headache. Headache is one of the most distressing postspinal complications from the patient's standpoint. This complication may arise following a diagnostic spinal puncture as well as spinal puncture followed by the injection of a spinal anesthetic agent. Many theories have been advanced to explain this complication Although there may be any number of secondary factors which may contribute to the production of postspinal puncture headache there seems little doubt that the primary exciting factor in the production of this complication is a decrease in cerebrospinal fluid pressure. Supportive evidence for this contention may be listed as follows: (1) where figures are available the cerebrospinal fluid pressure in patients suffering from postspinal puncture headache is usually lower than it was before the spinal puncture; (2) restoration of the

cerebrospinal fluid pressure by the subarachnoid injection of normal saline solution will afford relief; (3) there is ample evidence that the dural opening through which the spinal needle entered may be present as long as fourteen days following spinal puncture, (4) the headache is made worse by jugular compression and by sudden movements of the head, and (5) Wolff[8] and his co-workers have definitely shown that there are certain pain-sensitive areas in the head, the stimulation of which will produce discomfort, interpreted by the patient as headache.

Weintraub and his associates[7] have reported the presence of orthostatic hypotension or tachycardia, or both, in 50 per cent of their patients suffering from headache following the use of spinal anesthesia for delivery. From these observations they concluded that when spinal anesthesia is used for delivery, another factor contributing to postspinal puncture headache is introduced, namely, an orthostatic hypotension due to release of intra-abdominal pressure following delivery. They cited as support for this theory, the fact that they were able to relieve the headache not only in the patients in whom they could demonstrate hypotension but in the other 50 per cent as well by the application of tight abdominal binders.

Wolff and his co-workers have demonstrated the pain-sensitive areas in the cranium as: (1) the great venous sinuses; (2) the venous tributaries to the sinuses on the surface of the brain, (3) certain of the dural arteries at the base of the brain and (4) certain cerebral arteries at the base of the brain.

A possible chain of events leading to stimulation of the pain-sensitive areas in the brain and producing a postspinal puncture headache is as follows: (1) lowering of the cerebrospinal fluid pressure owing to decreased volume, which (2) results in a greater differential between the cerebrospinal fluid pressure and the intracranial venous pressure, bringing about (3) dilatation of the venous structures and perhaps some increase in brain volume because of venous dilatation and possibly edema, and (4) this venous dilatation results in tension and stimulation of the pain-sensitive areas previously mentioned

The headaches may be frontal, temporal or occipital. Throbbing in the head is produced on sitting or standing. Sometimes the main complaint may be stuffiness in the ears, while other patients may have little headache but complain of stiffness at the nape of the neck or shoulders.

Prevention of Postspinal Puncture Headache. Although it is difficult to evaluate the benefits of any individual measure designed to decrease the incidence of postspinal puncture headache, the adoption of certain measures would seem reasonable even though it cannot be said that strict adherence to any one or all of these will prevent a postspinal puncture headache in any particular patient.

The patient's reaction to discomfort related to the head is in no way different from his reaction to pain in other parts of the body, and for this reason it is probably wise to select some other form of anesthesia for patients who have a history of severe headaches or who are obviously prone to react poorly to any type of pain. Although it does not necessarily follow that a patient who has had a headache following a previous spinal puncture will necessarily have one after every subsequent puncture, it is perhaps wise not to employ spinal anesthesia

when the patient gives a history of a severe headache following a previous spinal puncture unless it is thought that spinal anesthesia offers a major advantage *over all other forms of anesthesia.*

Anything which tends to reduce the leakage of spinal fluid from the subarachnoid space after spinal anesthesia can be expected to decrease the incidence of spinal puncture headache. There is considerable evidence that the use of smaller caliber needles is followed by a decrease in the incidence of postspinal puncture headache. Multiple spinal punctures probably tend to contribute to a greater amount of postpuncture leakage of cerebrospinal fluid and probably to an increased incidence of headache. If the patient is held very quiet during the spinal puncture the danger of a dural tear probably is lessened. Close attention to adequate hydration of the patient during the course of the operative procedure and after operation probably contributes to a lessened incidence of postpuncture headache.

It is doubtful whether insistence on the horizontal position without a pillow after operation is of any value in the prevention of postpuncture headaches. Apparently the patient who will develop a headache following spinal puncture will do so whether or not he is kept flat in bed for twenty-four to forty-eight hours after a spinal puncture.

The *treatment* of headache following spinal anesthesia, for the most part, is conservative and not very satisfactory. Patients with the milder types generally respond to rest in bed with the bed level or in the head-down position. Relief is sometimes obtained with mild analgesics, but more stubborn cases require constant medication with salicylates and occasionally an opiate. The more intractable type of postspinal headache should be investigated carefully. A lumbar puncture should be done and spinal fluid dynamics determined along with microscopic and bacteriologic investigations of spinal fluid to rule out meningitis. When the spinal fluid pressure is low, benefit has been obtained by returning it to normal by the injection into the subarachnoid space of physiologic saline solution. When the spinal fluid is elevated (and it is sometimes with postspinal headache), however, it should be returned to normal by the withdrawal of spinal fluid. It requires a little courage on the part of both the patient and the operator to perform another spinal puncture when both of them know that the headache was caused by the first puncture. If the headache is not relieved permanently following restoration of the cerebrospinal fluid pressure by the injection of normal saline solution, repetition of the procedure once or twice may result in permanent relief.

Although pituitrin has been used both prophylactically and therapeutically in the treatment of postspinal puncture headaches for many years, its value is questionable. The same can be said for caffeine sodium benzoate. Targowla and Lamache[6] suggested the use of ergotamine in the treatment of spinal puncture headaches and Guttman[1] reported benefit from this drug. On the other hand, Lennox, von Storch and Solomon[2] stated that ergotamine was of no value in the treatment of drainage headache.

Cranial Nerve Palsies. From time to time we read reports of cranial nerve palsies following spinal anesthesia. While the abducens or sixth nerve is the one most frequently affected, there have been reports of palsies of almost all of

the cranial nerves. The mechanism by which a cranial nerve is paralyzed is difficult to explain, and this is a very rare complication. There is no treatment of this condition and recovery can be expected in almost every instance.

The Cauda Equina Syndrome. Some manifestations of the so-called cauda equina syndrome are usually thought of when postoperative neurologic complications are mentioned. This complication is brought to the anesthesiologist's attention because the patient fails to regain the use of his lower extremities in the usual time following spinal anesthesia. On examination, a certain amount of loss of both motor and sensory function is generally found to involve some part of the lumbosacral nerve distribution. Associated conditions may be varying degrees of urinary retention and incontinence of feces with loss of tone of the anal sphincter. This loss of sensation may involve only the saddle area, one or both legs or the entire body below the umbilicus. As was pointed out previously, an examination of these patients reveals that the basic lesion is in the region of the caudia equina where the nerves have met the anesthetic agent in its highest concentration.

The following case report illustrates this complication:

A white man, aged 42, a bartender, complained of cold legs for the past two years and associated cramps in the calf muscles for the last six months. A diagnosis of thromboangiitis obliterans was made and hospitalization for further investigation, with possible lumbar sympathectomy, was advised. He was given 14 mg. of tetracaine (pontocaine) hydrochloride and 2 66 cc. of 10 per cent dextrose for spinal anesthesia for skin temperature readings. The spinal puncture was made in the third lumbar interspace. Anesthesia developed to the eighth thoracic segment. After twenty-four hours the anesthesia was still present and the patient was paralyzed from his waist down. A spinal puncture at that time showed an initial pressure of 50 mm. of water, total protein 347 mg., and sugar 21 mg. per 100 cc., with 57 lymphocytes. Approximately thirty hours after the spinal anesthetic was administered an exploration of the lower thoracic and upper lumbar cord was performed, under endotracheal ether anesthesia, for what was thought to be a spinal fluid block. No block was found and the cord showed only slightly increased vascularity.

The patient remained in the hospital for three months and showed but little improvement. There was improvement in the sensation over the area supplied by the second lumbar nerve and a slight return of motor power in the feet. Although he voided voluntarily, a small amount of residual urine with an associated pyuria persisted throughout his hospital stay. He was discharged from the hospital without ever having regained the use of his lower extremities. During his stay at home over the next fourteen months there was no improvement in his condition. He died seventeen months after the development of the complication. A complete necropsy, including the brain and spinal cord, was obtained. The pertinent pathologic observations were in the spinal cord.

The following is a comment by the neuropathologist: "The principal pathologic observation is the loss of nerve fibers in the root of the cauda equina and the regeneration of fine nerve fibers in the anterior root. The degeneration of the posterior columns of the spinal cord is unquestionably secondary to destruction of the posterior roots. The fibrous thickening and cellular proliferation in the meninges may be viewed as the final stage of an inflammatory process, whether induced by chemical irritation or infection. The pathologic observations are approximately the type one would expect in a lesion one to two years of age. The partial sparing of some roots and the regeneration

of others would account for the retention of some bladder function and sensation. There are no vascular lesions suggestive of thromboangiitis obliterans. I believe that the changes in the anterior roots which were first interpreted as neurofibromatosis are regenerative phenomena. The observations are consistent with, although not pathognomonic of, the cauda equina syndrome of spinal anesthesia."

Prevention of Postspinal Neurologic Complications. The following is a regimen which has been suggested in an attempt to prevent postspinal neurologic complications:

1. Very close attention should be paid to the cleansing and sterilizing of apparatus used in the administration of spinal anesthesia. The routine rinsing of syringes and needles with sterile isotonic solution of sodium chloride immediately before their use is an additional precaution.
2. Drugs should be used from manufacturer's ampules whose labels are legible, whose walls are intact and whose contents on routine inspection before use are clear and free from insoluble particles or crystals.
3. Ampules containing spinal anesthetic drugs should be sterilized by soaking them in nonirritating, highly colored sterilizing solution. The addition of a strong concentration of dye to these solutions in which the ampules are immersed is of value in detecting the occasional defective ampule into which the sterilizing solution may have leaked. Irritating solutions containing alcohol, phenol or formaldehyde should not be used because of the danger of their entering the ampule through microscopic breaks and in turn being injected into the subarachnoid space. Many of the spinal anesthetic agents now in use can be sterilized by autoclaving and this circumvents the possibility of a sclerosing sterilizing solution entering the ampule.
4. Solutions containing even a faint suggestion of turbidity or cloudiness should be discarded.
5. Spinal punctures should not be made through or near areas of infection.
6. Spinal anesthesia should not be given to patients with known spinal cord disease, such as tabes dorsalis, multiple sclerosis, pernicious anemia with symptoms of combined system disease, and tumors of the spinal cord. Patients who have herniated intervertebral disks with signs of peripheral nerve paralysis, loss of bowel or bladder function or with an elevation of the total protein content of the spinal fluid should not be given spinal anesthesia.
7. Patients suffering from known virus infections, such as poliomyelitis or chickenpox, should not be given spinal anesthesia.
8. A history of delayed return of motor function or severe paresthesias following a previous spinal anesthesia should be considered a contraindication to the subsequent use of this type of anesthesia.
9. If the spinal puncture causes a radiating paresthesia, the anesthetic agent should not be injected until adjustment of the needle has freed the patient of this pain. We have seen 2 patients in whom this warning was not heeded and the administration of the spinal anesthetic agent caused a unilateral paralysis of one leg
10. A persistently bloody spinal tap contraindicates the injection of a spinal anesthetic agent.
11. Routine determination of the spinal fluid dynamics should be carried out

on all patients complaining of intractible back pain or pain that seems out of proportion to the pathologic condition for which the surgical procedure is being performed. Experience has shown that spinal cord pathology (metastatic disease or primary carcinoma) can be detected in a certain number of these patients by such a routine.

12. When it has been difficult or impossible to obtain the desired height of anesthesia by the ordinary methods a spinal block should be suspected. It is advisable to terminate such a spinal anesthesia by flushing out the subarachnoid space with isotonic solution of sodium chloride in order to remove any residual anesthetic solution that may have been deposited in the subarachnoid space.

Management of the Cauda Equina Syndrome Following Spinal Anesthesia. Since the loss of bowel and bladder function from the standpoint of the life of the patient is probably the most serious of all of the symptoms of the cauda equina syndrome, some discussion of the management of this complication is warranted. Each step in the sequence of events leading up to the mishap demands careful investigation. A complete history and physical examination in addition to a review of the preanesthetic information should be obtained. The extent of the impairment of the nerve function must be ascertained. It is of paramount importance that the functional state of the bowel and bladder be determined so that treatment, if needed, can be instituted immediately. Tidal irrigation of the bladder, as described by Munro,[3, 4] offers a real chance for recovery of function without infection of the urinary tract. It is extremely difficult to give an effective cleansing enema by ordinary methods to a patient whose rectal sphincter is incompetent. However, if a large Foley catheter is inserted into the rectum and the cuff inflated an effective enema can be administered.

In order that preexisting pathologic changes in the spinal cord may be detected early, any patient in whom there is evidence of a postspinal cauda equina complication should have an investigation of the spinal fluid dynamics. In conjunction with this maneuver it is advisable to irrigate the subarachnoid space with isotonic solution of sodium chloride to insure the removal of any remaining anesthetic agent. This attempt to remove any residual anesthetic agent takes on additional significance when a spinal fluid block is discovered. When the abnormalities of the spinal fluid are limited to an elevation in the total protein and cell count, daily spinal punctures for the withdrawal of fluid should be performed.

During the recovery period, the duration of which may be extremely variable, the nursing routine must be a vigorous one if decubitus ulceration, ankylosed joints, malnutrition and muscular atrophy are to be avoided.

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EXPERIENCES WITH CARDIAC ARREST

FRANK H. LAHEY AND EDWIN R. RUZICKA

The first death attributed to anesthesia occurred on January 28, 1848.[6] This was a little more than a year after the introduction of ether anesthesia and about two months after the introduction of chloroform in obstetrical anesthesia. There were enough reported facts about this first death under anesthesia, which incidentally was an ether anesthetic, to make one feel it may have been a cardiac arrest. One hundred years later the problem of cardiac arrest is still present and, if anything, is more pressing than ever.

Barber and Madden,[4] in a consideration of the historical aspects of cardiac resuscitation, pointed out that the earliest reports on manual massage for cardiac resuscitation were the experimental studies of Schiff in 1874. Work on dogs and rabbits appeared at intervals from 1898, when Tuffier and Hallion confirmed the work of Schiff, until 1903. These reports seemed to indicate an ability of cardiac massage, of an electrical current, and of Locke's solution injected into the coronary arteries frequently to restore the heart beat of dogs and rabbits. Niehaus, in 1889, first attempted cardiac resuscitation by manual massage, but was unsuccessful. Maaj, in 1900, was the first to report a partial success. He was able to reestablish cardiac pulsations and spontaneous respirations for eleven hours. Ingelsbrid, in 1901, first succeeded in resuscitating the heart but it was not reported until 1904. Starling and Lane, in 1902, first reported a successful case of resuscitation of the human heart, using subdiaphragmatic massage. Barber and Madden reviewed the literature to 1945 and found that 143 cases of cardiac arrest had been reported. This small number of cases from 1848 to 1945 makes the incidence of cardiac arrest appear to be very low. If the reported cases give an accurate idea of the relative frequency of this complication in former years, then something has happened in recent years to make cardiac arrest occur more frequently. The probability is that this is not the case but that we are all now more aware of the possible occurrence of this condition and that more anesthetists and surgeons are on the lookout for it than previously.

Our own experience and conversation with, and letters from, men in all sections of the country reveal an increased frequency and, consequently, an increased consciousness of this problem. This is an emergency requiring prompt decisions, radical treatment and a knowledge of the very short time available in which to bring about a successful outcome. It is important to realize that cardiac arrest, while infrequent, is by no means a rare complication and is one which, to make life-saving possible, requires instant planned action, without which the heart will all too frequently be restored to action but unfortunately at a time when mental deterioration has already taken place.

Originally published in Surgery, Gynecology and Obstetrics, 90:108–118 (Jan.) 1950

The expectancy of death during operation and anesthesia from all causes is 1 to 1,000 in a large number of cases in five teaching hospitals in three continents. The expectancy for cardiac arrest is undetermined but much less. The important point to remember, however, in cardiac arrest is that in the past many have been lost who could have been saved.[10]

INCIDENCE

In the past seven years there have been 13 cases of cardiac arrest in the Lahey Clinic operating rooms. Bailey,[3] who has had an extensive experience with this problem, has apparently had about 2 cases a year. This concurs with others' experiences and our incidence. We may assume that in a busy operating room suite 1 to 2 cases may be expected per year, and we must assume that whether these patients live or die is based upon how well the operating personnel is organized to deal with the instances which occur.

DIAGNOSIS

The surgeon is not usually the first to establish a diagnosis in this complication unless the operation he is doing is of such character that he happens to have an artery under direct vision and notes cessation of pulsation in it, or the chest is open and the heart or large vessels are visible. The anesthesiologist is most frequently the first to become aware of sudden cardiac arrest, and it is *he who in a great majority of cases will need to notify the surgeon of the need* for immediate action. A constantly alert watch of the patient must be maintained for this condition by both the anesthetist and surgeon since cardiac arrest may occur at any time during the induction and maintenance of the anesthesia and at any stage of the operative procedure. The type of operation performed is of no assistance in anticipating or preventing sudden cardiac arrest since it may occur during any type of operative procedure. It may also occur with any anesthetic agent or combination of agents. This includes spinal anesthesia when used as the sole anesthetic agent. In our group of 13 cases the ages of the patients ranged from 7 to 65 years. There were 8 males and 5 females. Premedication consisted of 1/6 grain of morphine sulfate and ⅓ grain of pantopon plus 1/150 grain of scopolamine and 1½ grains of nembutal. Cardiac arrest occurred during the following operative procedures chest operation, 3 cases; abdominal operation, 4 cases, thyroid operation, 2 cases, sympathectomy, 1 case; brain operation, 1 case, laryngoscopy, 1 case, induction, 1 case.

The anesthesiologist must notify the surgeon as soon as the pulse and blood pressure disappear If he even suspects that there has been a cardiac arrest, the surgeon must be asked to check arterial pulsations. False alarms will inevitably occur but must be understandingly tolerated. The short time during which treatment, to be effective (three and one-half minutes), must be applied means that the anesthesiologist and surgeon cannot waste time in useless checking, but must be ready for instant decision and rapid preparation for emergency measures.

Equipment for the management of these cases, needle and instruments already sterilized, and drugs should be at hand ready for use at all times in the operating room Without this forehandedness the time loss and the inevitable confusion will result in restoration of cardiac activity too late to retain full and

normal cerebration. If this paper does nothing more than to prompt surgeons to be aware of the possibility of this complication and be prepared for it, it will have been worth writing.

ETIOLOGIC FACTORS

There are few instances in which the causation of cardiac arrest may be definitely ascertained. Several factors of possible etiologic significance are known. Any one or all of these may play a part in precipitating this emergency. There are certainly other factors which we do not know of at present and which probably play a part in sudden cardiac arrest. The ability of chloroform, cyclopropane, and ethyl chloride[17] to sensitize the heart to the action of epinephrine is well known. Hypoxia[7] sensitizes the heart and causes an increased content of epinephrine in the circulating blood. Excitement causes an increased epinephrine content in the blood. Hypoxia[9] may sensitize the carotid sinus with a resultant reaction to stimulation of the carotid sinus, producing inhibition of cardiac activity. Intravenous barbiturates[8] and cyclopropane have a parasympathetic effect on the heart. Stimulation of the vagus nerve may inhibit cardiac activity.[16] There may be a sensitivity to a drug as when sudden cardiac arrest occurs under spinal anesthesia alone. Too deep anesthesia causes sudden simultaneous cardiac and respiratory arrest. This list of possible causes is undoubtedly incomplete but it furnishes the basis for the plan of treatment for this complication.

Having personally participated in some of these cases, both of us are conscious of how disquieting they are, how difficult it is for surgeon, anesthetist, and particularly for the other operating room personnel to act and function effectively without panic and without undue loss of time. We have learned from our experiences that three and one-half minutes, the limit of time available, is too short to trust to anything but planned, prepared, and practiced effort. If one depends upon improvisations such is the dramatic nature of the situation that excitement and panic instead of calm and logical steps will dominate it. What is needed is a definite practiced plan of action, the only way by which the necessary time can be preserved to save, not life, but particularly the intellect. In all of these cases it has been possible to restore cardiac action but in some so late that cerebral damage has occurred and the patients have died a few days after operation.

TREATMENT

Weinberger, Gibbon, and Gibbon[21] have demonstrated experimentally that treatment must begin within three and one-half minutes of cessation of circulation of blood. These workers showed that interruption of circulation to the brain for three and one-half minutes or longer resulted in permanent changes in psychic behavior. Interruption for eight minutes and forty-five seconds was incompatible with life for more than a few hours. Unfortunately, this work is all too well borne out by our and others' clinical experiences.

A plan of action which we have presented before and see no reason as yet to change is suggested. It may be wise to post some plan of action in every operating room. It consists of. (1) artificial respiration with 100 per cent oxygen, (2) immediate cardiac massage by the surgeon—this is the all important

step; (3) drug therapy consisting of the use of procaine and epinephrine; and (4) general methods of treatment including the administration of intravenous fluids and the institution of 5 to 10 degree Trendelenburg position.

When procaine and epinephrine are on the instrument table it is good practice to do a cardiac puncture, aspirate blood, and inject the solution before beginning the steps of cardiac massage (Fig. 469). This step has value since we believe some hearts showing clinical signs of cardiac arrest are not actually arrested. This step should *not* be included in the treatment if the sterile syringes and solutions are not ready for instant use since their procurement will result in a fatal loss of time.

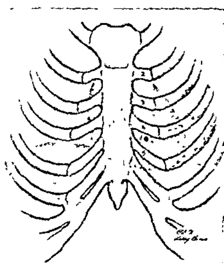


Fig. 469. The point at which the needle is inserted for the intracardiac injection is shown by the black dot. The plunger of the needle must be withdrawn so that the syringe fills with blood to demonstrate that its point is within the ventricle. If it becomes necessary to open the chest to accomplish manual massage, the incision is best made in the fourth interspace, cross cutting its sternal cartilage in order to make room for the hand.

Artificial respiration with 100 per cent oxygen presupposes an unobstructed airway. An endotrachial tube should be inserted if it is not already in use. This can be done by anesthetists expert in their use while other measures are being carried on. Artificial respiration maintains a high concentration of oxygen in the alveoli and also has some mechanical effect in maintaining a slight circulation of the blood. Artificial respiration may need to be continued from a few minutes to several hours after the reappearance of cardiac activity. Return of cardiac activity does not always signal immediate return of respiratory activity.

Artificial respiration alone is insufficient and is useless unless the circulation is maintained. In cardiac arrest this portion of the treatment must be undertaken by the surgeon Cardiac massage is the all important factor of the treatment and must be started without delay if a favorable outcome is hoped for. The approach to the heart depends on the operative procedure in which the arrest occurs but resolves itself into three routes· (1) transperitoneal subdiaphragmatic, (2) transperitoneal transdiaphragmatic, and (3) transthoracic.

The rate of cardiac massage has been quoted at various figures. Nicholson recommended 80 compressions per minute. There have been many guesses but Gunn has offered a really plausible rate with an explanation for his statement.

He maintained that massage of the heart is not a question for indifference but that attention to detail is important. He even suggested practice for this maneuver. Gunn stated that compression should be gradual and relaxation abrupt with rate of compression at most only half the normal rate. The massage must be interrupted at regular short intervals for a few seconds in order to allow spontaneous beats to

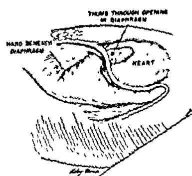


Fig 470.

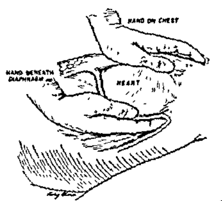


Fig. 471.

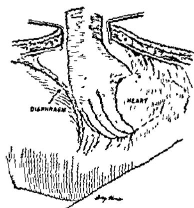


Fig. 472.

diaphragm with counterpressure on the chest by pushing the heart against the chest wall and sternum It is usually not possible to obtain the degree of compression shown. This is a doubtful method in terms of effectual cardiac massage.

Fig. 472. In this illustration is shown the incision between the fourth and fifth ribs and the hand above the diaphragm grasping the heart in order to carry out direct compression of the heart. This is the most effectual method of maintaining circulation when prolonged cardiac arrest has occurred.

develop. The lower than normal rate of compression was recommended in order to allow the ventricles to fill and because it is a subnormal rate of beat that one is attempting to elicit, namely, the rate at which the arrested heart would start beating again. A prompt return of heart beat probably is the result of massage plus epinephrine. Gunn has emphasized that massage is used to stimulate the heart and maintain circulation and that the most important thing is stimulation of the heart. In the excitement of the moment mechanical stimulation of the heart can be

bined with procaine. This has been done with full awareness of the propensity of epinephrine to cause arrhythmias and possibly ventricular fibrillation. This procedure has been followed in every one of our cases and while in some cardiac action has been restored too late to preserve normal cerebration and life, in every patient the cardiac beat has been restored.

Procaine given intravenously is of real value in handling patients who develop cardiac arrhythmias during thoracic surgery. The topical use of procaine is also effective in treating ventricular fibrillation. The intravenous and topical use of procaine now seems soundly established as a means of treating cardiac irregularity and sudden cardiac arrest.

We would like to re-emphasize the fact that the true value of drug therapy in cardiac arrest is to intensify the effect of the real mainstay of the treatment of this condition, that is, cardiac massage. Since we have become more keenly interested in trying to save more patients with cardiac arrest it has been our practice to have in the operating rooms, ready and mixed, 0.5 cubic centimeter of epinephrine 1:1000 and 9.5 cubic centimeters of procaine, 1 per cent, so that both drugs may be administered in a single injection.

When the diagnosis of cardiac arrest is made, an injection of the 10 cc. of the already mixed and available procaine and epinephrine is done by the quickest and most easily accessible intravenous route. If a choice of intravenous routes is possible, an antecubital vein is preferred since it is closer to the heart than is a leg vein. Age and debilitation may be factors in causing one to administer only 5 cc. of this solution. If the heart has not resumed activity soon after cardiac massage has begun, the next 5 cc. may be injected directly into the heart, preferably the cavity of the right auricle or ventricle, the needle being inserted directly into the cavity and its position proved by the ability of the surgeon to withdraw blood freely into the barrel of the syringe. The barrel containing the solution is then connected and the material introduced.

Following this procedure, if cardiac activity is slow in returning, it is probably wise to omit the epinephrine until there is some return of automatic cardiac activity, but procaine should be repeated or kept running in a continuous intravenous drip until regular cardiac action is restored.

Many other drugs[20] have been used in these emergencies. There is little reason to use a great number of these agents. Restriction of use of a variety of drugs enables one better to evaluate the efficacy of the two which, by experience, appear to have given the most reason for their use.

RESULTS

The cases collected by Barber and Madden numbered 143. Forty-eight of these patients, or 33 per cent, were treated with complete success. Bailey had a personal experience with 40 cases of cardiac arrest. He was able to revive 13 patients and of these, 4 survived. We have now had 13 cases of cardiac arrest, cardiac action has been restored in every case but only in 5 cases, or 38 per cent, has there been recovery with normal mentality. One other patient recovered with normal mentality, but died on the second postoperative day from acute cardiac failure, this case is not included in the 5 successful cases.

COMPLICATIONS

Ventricular fibrillation[13] is reported in the literature to be the most frequent complication of cardiac resuscitation and when it occurs it must, of course, be treated promptly. We have not seen it occur in any of our cases and feel that the possible reason may be the employment of procaine in the initial treatment. When the heart is under direct vision and fibrillary cardiac movements are preserved, Beck[5] recommended the use of cardiac massage first. If unsuccessful, he advocated the injection of 5 cc. of 2 per cent procaine into the cavity of the right heart and continuation of cardiac massage. Beck has also stated that procaine, 5 per cent, or "metycaine hydrochloride" (*New and Nonofficial Remedies*), 10 per cent, applied to the surface of the fibrillating ventricle may be effective in augmenting heart action. This elevates the threshold of cardiac muscle to incoming stimuli and renders ineffective the minimal stimulus producing the fibrillation.

Beck has also used the electrical countershock method in treating ventricular fibrillation. Two padded silver electrodes, 25 sq. cm. in size, are moistened in sterile isotonic solution of sodium chloride and applied to the anterior and posterior surfaces of the heart. An electrical current of 1 to 1.5 amperes through a 60 cycle alternating current is applied for 0.1 to 0.5 second. The heart muscle is contracted and brought to a standstill. Then a normal rhythm may be renewed. Should the first shock fail, manual massage is resumed, procaine is injected as previously recommended, and the shock repeated. If failure still results, Beck recommended the use of 1 cc. of epinephrine, 1:1000, or 5 cc. of calcium chloride, 1 per cent, to be injected into the right ventricle to increase its tone and elasticity. The shock is again repeated and, it is stated by Beck, the fibrillation is usually overcome. Electrical countershock therapy, while experimentally interesting, is clinically impractical in most cases in which these emergencies occur.

PATHOLOGY

Revival of cardiac and respiratory activity even to the levels existing prior to the cardiac arrest does not signify assurance that these patients will survive. These patients often die in the period of one to fifteen days postoperatively. During this time many of them show every sign of marked damages to the central nervous system (especially those with cerebral damage). The sensitive cerebral cortex cells are first affected by interruption of the circulation, with resultant ischemia and anoxia. It is not usual to find demonstrable macroscopic or microscopic evidence of damage to the brain in these cases In the heart itself often the only gross pathologic changes seen are the result of rough or forceful cardiac massage. It is not rare to find a hemopericardium following blind intracardiac injections. With these demonstrated findings in mind it is important to remember the need for gentleness and care in attempts to restore cardiac action.

In 1946, Hawkins, McLaughlin, and Daniel[12] reported the case of a patient who died 26 days following cardiac arrest of ten to eleven minutes while in the operating room. They found degeneration of the cerebral and basal ganglions. Microscopically, there was disappearance of most of the pyramidal cells of the cerebral cortex and an increase in astrocytes and microglial pro-

liferation, especially in the occipital cortex. Chromatolysis was evident in the few surviving cells. Destruction of the occipital cortex and superior temporal gyrus was severe. Blood vessels were not abnormal; there was no thrombosis or perivascular hemorrhage.

REPORT OF CASES

CASE 1. The cardiac arrest in the reported case of pulmonary lobectomy by Adams and Hand from this clinic occurred in a man, aged 20 years, two hours after the start of cyclopropane-oxygen anesthesia when a suction catheter was introduced into the trachea by way of the endotracheal tube. The patient gave three convulsive coughs, and cardiac and respiratory activity ceased. This was, of course, plainly visible as the chest was open and the heart exposed. This patient was treated with cardiac massage

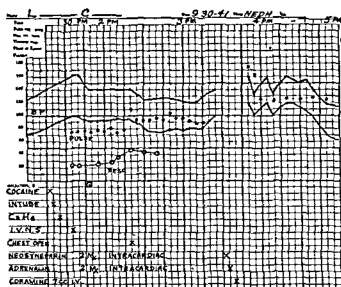


Fig. 474 (Case 1) Anesthesia chart. This is the first case of cardiac arrest. Since lobectomy was being performed, the chest was open and manual cardiac massage was done for twenty minutes.

supported by drug therapy. This case strengthened the belief that cardiac massage was the mainstay of the treatment for cardiac arrest. It was also felt then that drug therapy was of assistance but only if specific drugs could be found. Procaine was thought to be one of these drugs. This case apparently fits in well with those instances of cardiac arrest which can be traced to a vagovagal reflex. This, the first case of this series, resulted in complete recovery (Fig. 474).

CASE 2. A woman, aged 35 years, was undergoing hysterectomy following dilatation and curettage. When a clamp was placed on the uterus, sudden cardiac arrest occurred. This was thirty minutes after induction of spinal anesthesia with 17 mg. of tetracaine hydrochloride and dextrose solution and ten minutes after the intravenous administration of morphine sulfate, $\frac{1}{6}$ grain (10 mg.), and scopolamine, $\frac{1}{150}$ grain (0.4 mg.). Artificial respiration by manual pressure on the breathing bag was begun immediately, as was transperitoneal subdiaphragmatic cardiac massage. One cubic centimeter of 1 to 1,000 epinephrine solution was also given intracardially. In about five minutes heart action had returned, respirations returned twenty minutes later. The operation was terminated. After operation, for forty-eight hours the patient had hyperirritable reflexes with a Babinski reflex. Reflexes became normal, and the patient made an uneventful

recovery except for a loss of memory for events of the twenty-four hours before operation.

CASE 3. A man, aged 31 years, undergoing cholecystectomy, had cardiac arrest thirty minutes after induction of spinal anesthesia with 18 mg. of tetracaine hydrochloride and dextrose solution and twenty minutes after the operation was begun, while the cystic duct was being exposed. An endotracheal tube was introduced and artificial respiration begun. *Subdiaphragmatic cardiac massage was carried out for a few minutes.* Then an incision was made in the dome of the diaphragm and transdiaphragmatic cardiac massage was carried on. Cardiac activity reappeared in about fifteen minutes. The operation was completed rapidly.

Seven hours after operation the patient was unconscious, hyperventilating, and showing hypertonic rigidity and carpopedal spasm. In two days he exhibited a flaccid paralysis. On the fifth day tracheotomy was done because of the respiratory obstruction which a flaccid epiglottis created. The temperature remained high, cord bladder developed, and the patient died on the fifteenth day.

The abnormalities noted at necropsy were inconclusive. There was slight cerebellar coning from pressure and terminal bronchopneumonia. Microscopic sections revealed diffuse slight edema and slight gliosis. Cause of death not determined pathologically.

CASE 4. A woman, aged 44 years, undergoing splanchnicectomy for essential hypertension, had cardiac arrest after a few warning signs, which is unusual. Twenty-five minutes after induction of spinal anesthesia with 20 mg. of tetracaine hydrochloride and dextrose solution, during which time the patient received 0.2 mg. of pentothal sodium (*N. N. R.*), and fifteen minutes after the operation was begun, the surgeon had exposed the lumbar sympathetic chain, when the patient was noted to be cyanotic around the lips and using her accessory muscles of respiration. Administration of oxygen by manual positive pressure was of no help, and cardiac and respiratory arrest occurred suddenly.

The patient was placed on her back and intubated; artificial respiration was begun and epinephrine, 0.5 cc., was injected intracardially. In three minutes heart sounds were heard, but no pulse or blood pressure was elicited for another thirty minutes. The operation was immediately terminated. Although the patient looked well oxygenated and showed no unusual signs, she never regained consciousness and died on the third postoperative day.

Postmortem examination did not reveal damage to the brain grossly or microscopically. Pulmonary atelectasis, hydrothorax on the left side, pulmonary congestion and edema, laceration of a coronary vein with hemopericardium of 300 cc., myocardial hypertrophy and dilatation were present. The immediate cause of death was anoxemia according to the report of the pathologist It is likely that this patient had a complete or total spinal anesthesia preceding the anoxemia.

CASE 5. A man, aged 47 years, was undergoing division of a sensory root for trigeminal neuralgia when he suddenly took two deep breaths, and cardiac and respiratory activity ceased. This occurred while the fibers of the second and third divisions of the trigeminal nerve were being divided. The patient was placed supine and artificial respiration begun About twelve minutes later an incision in the upper part of the abdomen was made and subdiaphragmatic cardiac massage begun. Epinephrine, 0.75 cc. intramuscularly, produced no change. Epinephrine, 0 5 cc., was injected into the heart while massage was continued On piercing the heart muscle with the needle a few spontaneous movements were felt. Cardiac activity was resumed after an arrest of about twenty minutes. The operation was terminated.

In one hour the patient reacted to painful stimulation and groaned. He exhil hypertonicity of all extremities and, at times, a coarse tremor. Bilateral pneumoth developed, and 1,300 cc. of air were removed from the left side of the chest. He n regained consciousness and died on the seventh postoperative day. The supervi anesthesiologist felt that this patient may have reached the fourth stage of e anesthesia when cardiac and respiratory arrest occurred.

Postmortem examination did not reveal gross or microscopic damage to the bi There was confluent bronchopneumonia, which was called the immediate caus death. Too much time was lost in getting patient out of an upright position chai which the sensory root division was done.

Case 6. A man, aged 65 years, was undergoing a thyroidectomy when cardiac a occurred while the anterior edge of the sternomastoid muscle was being freed. ' was twenty minutes after induction of anesthesia with ethylene-oxygen and subseq anesthesia with ether-oxygen, and five minutes after the operation was begun.

Artificial respiration was immediately begun, and 1 cc. of 1 to 1,000 solutio epinephrine was given intravenously. In 10 minutes cardiac and respiratory act appeared as before operation. The operation was then completed. The postopera course was normal on the first day. On the second day patient conversed with a visi physician and then suddenly died. He was a known cardiac cripple who had long treatment for cardiac decompensation and hyperthyroidism before operation. ' episode in the operating room may have been the evidence of a hypersensitive ca sinus.

Postmortem examination of the brain did not reveal damage grossly or micros ically. Cardiac dilatation, mitral stenosis, and arteriosclerosis were noted, cardiac fa given as the immediate cause of death.

Case 7. A man, aged 30 years, was undergoing a gastric resection. Cardiac a occurred suddenly when the right gastric artery was clamped. This was thirty min after induction of spinal anesthesia with 18 mg. of tetracaine hydrochloride and · trose solution and 0.4 gram of sodium pentothal (N. N R.). Morphine sulfate, grain (10 mg.), was given intravenously about thirty minutes before the cardiac ar Subdiaphragmatic cardiac massage was begun, and 2 cc. of epinephrine, 1 to 1, was injected into the heart. A tube was placed in the trachea and artificial respira begun. In about ten minutes pulse became palpable at a rapid rate, twenty min later respirations returned.

Postoperatively, the patient had convulsions and tonic contractions of the extrem lasting four minutes at a time. On the second day he became flaccid and had no n convulsions. The temperature remained high and the patient died on the third (Permission for autopsy could not be obtained

Case 8. A man, aged 49 years, was admitted to the hospital for biopsy of a suspe carcinoma of the vocal cord. He was short, obese, and had a history of drinking 1 q (0.95 liter) of alcohol daily for several years. Laboratory study revealed a blood pic characteristic of pernicious anemia with a hemoglobin level of 7.3 grams and an er rocyte count of 2,500,000. Urinalysis demonstrated an occasional leukocyte occasional granular and hyaline casts.

Pentothal and curare were selected for use The mouth and pharynx were spra with cocaine, 10 per cent. In the fifteen minutes preceding the suspension laryn copy, 60 units of intocostrin (N N R.) were given, followed after a five-mir interval by 0.5 gram of pentothal in a ten-minute period. When the suspension la goscopy was begun, the patient objected to the procedure. During the next fift

minutes an additional 20 units of intocostrin and 0.6 gram of pentothal were given. During this period two brief episodes of laryngospasm occurred. The anesthesiologist was palpating the pulse at the wrist when the pulse suddenly disappeared. Respirations ceased also. The surgeon had a long biopsy forceps in his hand and was looking directly at the cords when this occurred. He immediately used the forceps to hold the cords open while artificial respiration was carried on. When this produced no results in about three minutes, a flexible metal endotracheal tube was inserted and artificial respiration was carried on by pressure on the breathing bag of an anesthetic machine, using the closed system. Nikethamide, 15 cubic centimeters, was given with no effect. Ten minutes after the cardiac arrest 1 cc. of epinephrine, 1 to 1,000, was infiltrated into the heart by means of a long needle. This dose was repeated in five and in eight minutes. No effect could be noted. Artificial respiration was continued although livor mortis began to appear on the arms, legs, and back. Suddenly the pulse reappeared, approximately twenty-five to thirty minutes after it had disappeared. It was strong, with a rate of approximately 130 to 140 per minute. The livor mortis disappeared rapidly. In ten minutes the pulse rate dropped to 60 per minute and remained there for about five minutes. The rate varied between 100 and 120 per minute from then on. Respiratory efforts did not reappear until two hours after the cardiac arrest and one hour and thirty minutes after the return of cardiac activity. In three hours, respirations were regular at 10 to 12 times per minute, but were of a gasping character. The patient did not regain consciousness. His temperature rose rapidly to a high level and he died eleven hours after the cardiac arrest. Permission for autopsy could not be obtained.

This case was thought to be significant for several reasons. It was believed that some cardiac activity must have been present at all times even though the pulse and blood pressure were not obtainable. Epinephrine was the only drug used to stimulate the heart and apparently was of some value. Finally, a cause for the whole episode could be found. Apparently, a wrong choice of anesthetic agent was made. Under pentothal anesthesia, the spleen may dilate and retain some of the circulating red blood cells within itself. Curare may also cause impaired venous return to the heart and a lowered cardiac output because of widespread muscle relaxation or a direct relaxing effect on the smooth muscle of the arterioles. The clinical cardiac arrest in this case could then be said to have a probable beginning in hypoxia of the cardiac musculature caused by the reduction in oxygen-carrying red blood cells brought about by the action of pentothal and curare which resulted in disturbed or inefficient cardiac action.

CASE 9. A man, aged 58 years, had withstood a pneumonectomy for carcinoma of the left lung with involvement of the pericardium, with no unusual difficulty, when cardiac arrest occurred as the subcutaneous layers of the chest wall were being closed. Artificial respiration was begun, the chest was immediately reopened, and the heart was found to be still. Cardiac massage was begun and feeble cardiac activity quickly returned. No pulse or blood pressure, however, could be detected by the anesthesiologist. With the heart under direct vision, the surgeon noted that its activity was becoming more feeble. A mixture of 0 25 cc of epinephrine and 3cc. of procaine hydrochloride, 1 per cent, was injected into the right ventricle. The heart beat became more forceful and soon after very rapid and irregular. In order to prevent fibrillation, 4 cc. of procaine hydrochloride, 1 per cent, were injected into the cavity of the left ventricle. Immediately following the injection of procaine there was noticeable slowing of the pulse. The blood pressure was then 120 mm. systolic and 70 mm. diastolic and the pulse rate was 120. The chest was closed without further incident. Convalescence was not unusual. The patient had a loss of memory of events beginning twenty-four hours before operation and was understandingly hazy on the first few postoperative days.

This case showed that cardiac activity can be present with no detectable pulse or blood pressure.

CASE 10. A woman, aged 26 years with Cushing's syndrome was scheduled for exploration of the adrenal glands. Cyclopropane was used for induction at 7:30 A.M.; ether was begun at 7:35 A.M., and cyclopropane was discontinued. At 7:48 A.M. cardiac arrest occurred. An endotracheal tube was immediately inserted and artificial respiration with 100 per cent oxygen begun. Procaine, 2 cc. of a 1 per cent solution, and epinephrine, 2 cc., 1 to 1000, were injected into the heart with a long needle. The fifth interspace was quickly opened and cardiac massage carried out with two fingers against the heart. Injection of procaine and epinephrine directly into the ventricle was repeated. The cardiac beat quickly resumed and respirations soon followed. The blood pressure was 120 mm. systolic and 70 mm. diastolic and quickly fell to 55 systolic and

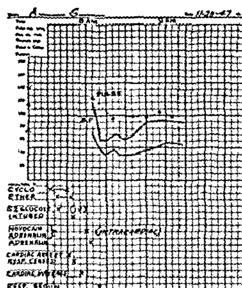


Fig. 475 (Case 10). Anesthesia chart. In this case cardiac arrest occurred early in the anesthesia period. The patient was given cardiac massage through an incision at the fourth left interspace. The surgeon introduced two fingers through the opening and massaged the heart against the chest wall.

40 diastolic, then gradually rose to 90 mm systolic and 50 mm. diastolic. The patient was returned to her room. She remained unconscious for forty-eight hours. At times she showed the picture of decerebrate rigidity with flexor spasm of both feet, spasticity of the right arm, and opisthotonos. Her eyes remained fixed with no reaction. Pulmonary edema occurred also The patient gradually improved after 48 hours of unconsciousness. She appeared childish, then euphoric, then more mature. She was anesthetized again eight days later with pentothal, curare, nitrous oxide, and oxygen. A bilateral resection of the adrenal glands was done uneventfully. This patient returned to her original mental state before operation (Fig. 475).

CASE 11. A woman, aged 22 years, came to the clinic because of congenital heart disease and a diagnosis of interauricular septal defect with poor cardiac reserve. On July 29, 1947, catheterization of the heart was carried out under local anesthesia with no ill effect. On August 1, 1947, the patient was scheduled for operation. Induction was begun with pentothal, 2.5 per cent. The pharynx and larynx were cocainized and an endotracheal tube was passed twelve minutes after induction was begun. Ether was begun with carbon dioxide absorption and circle filter. The patient was being put in position for operation in the operating room when cardiac arrest suddenly occurred.

Thoracotomy was immediately done and cardiac massage started. Artificial respiration with 100 per cent oxygen was carried on. Procaine, 4.5 cc., and epinephrine, 0.5 cc., were injected into the heart. Forty minutes after cardiac arrest 0.5 cc. of epinephrine was injected into the cardiac muscle and repeated every twenty minutes. The heart beat suddenly returned after one hour and five minutes; 10 cc. of procaine were injected into the ventricle. The pulse was 110 per minute and the blood pressure 90 mm. systolic and 60 mm. diastolic. Arrest again occurred after fifteen minutes. Activity returned after ten minutes for only a short period. It ceased and activity did not return again, although resuscitative measures were continued for another hour and fifteen minutes.

Autopsy revealed congenital heart disease with interauricular septal defect, aortic stenosis, hypertrophy of the pulmonary artery, hypoplasia of the aorta, and cardiac hypertrophy. Microscopic sections revealed minimal pulmonary tuberculosis and focal granuloma in the myocardium thought to be tuberculous in origin. Cardiac arrest was called the immediate cause of death.

CASE 12. A woman, aged 63 years, with hyperthyroidism had had long preparation with Lugol's solution and thiouracil before operation. Induction with 0.4 gram of

Fig 476 (Case 12). Anesthesia chart. Cardiac arrest occurred shortly after the patient was intubated. The rapid administration of procaine and epinephrine brought about a quick return of cardiac activity.

pentothal, 2.5 per cent, was begun and ether begun in ten minutes The patient was intubated within twenty minutes. She was placed in position, the area of operation prepared and a low neck incision was made. At this point, cardiac arrest occurred. Procaine, 4.5 cc., with 0.5 cc. of epinephrine was immediately injected directly into the heart ventricle by means of a long needle, its presence in the ventricle first being demonstrated by freely withdrawing 100 cc. of blood from the ventricle. Artificial respiration with 100 per cent oxygen was begun. Preparation for opening the chest was begun when the heart beat suddenly returned to its former rate and continued. The patient was watched carefully for twenty minutes. Then subtotal thyroidectomy was performed. Convalescence was normal and recovery complete with no cerebral changes (Fig. 476).

CASE 13. A 7 year old boy with congenital polyposis of the colon came to the clinic for colectomy. Induction of anesthesia with pentothal was uneventful, as was mainte-

nance with ether on carbon dioxide absorption and circle filter. Two doses, one hour apart of d-tubocurarine, 5 units, were given. Operation progressed uneventfully for one hour and twenty-five minutes, when cardiac arrest occurred. Intubation was performed immediately and artificial respiration begun. Subdiaphragmatic cardiac massage was started and 9.5 cc. of procaine, 1 per cent, and 0.5 cc. of epinephrine were injected into the heart through the left parasternal region. Procaine, 2 cc., was given intravenously. The heart began to beat again within five minutes of arrest. At first the beat was irregular, then rapidly became regular. The blood pressure was 100 mm. systolic and 40 mm. diastolic and the pulse 160. The operation was quickly terminated and the patient returned to his room. He died ten hours later in spite of all resuscitative procedures.

Postmortem examination revealed cerebral edema and patchy atelectasis of both lungs, with mucus plugs in the bronchi. The microscopic sections were of interest and are quoted: "In the Sommer's sector of the hippocampal convolution most of the nerve cells have disappeared and the remaining ones are darkly stained and shrunken. Astrocytes are slightly increased in number and size. Microglial cells are in transitional form and also have multiplied. In other parts of the cerebral cortex lesser degrees of nerve cell damage are noted. In some places nearly all of the nerve cells in the cortical layers, two and three, are shrunken and pyknotic and in others all the nerve cells in all the layers are affected this way. In some convolutions the majority of nerve cells are intact. The glial cells appear to be normal. Blood vessels and meninges are not changed. Scattered nerve cells in the thalamus, subthalamus, nucleus of Luys, substantia nigra, hypoglossal and inferior olivary nuclei are shrunken and pyknotic. This change was also noted in many of the Purkinje cells. The diagnosis was anoxic encephalopathy. Comment: Most of the nerve cell changes are acute, probably consistent with the duration of life after the cardiac asystole. The complete loss of nerve cells in one part of the hippocampal convolution and the gliosis are almost surely old lesions, probably related to anemic anoxia sometime in the past." The immediate cause of death was cerebral anoxia.

COMMENT

Since this paper was completed, 2 more cases of cardiac arrest have occurred. The first was in an obese 72 year old man in poor general condition, who had a large retroperitoneal mass. Spinal anesthesia was given with 0 012 gram of pontocaine and dextrose, light supplementary anesthesia was induced with pentothal and anesthesia maintained with cyclopropane. Sterile drapes were being adjusted when the pulse and blood pressure suddenly disappeared and the patient became cyanotic. An endotracheal tube was passed and artificial respiration with oxygen was begun. The surgeon quickly made an incision as planned for the operation, through the sixth left interspace. The heart could be seen beating regularly above the diaphragm. At this time the pulse and blood pressure suddenly reappeared and the cyanosis disappeared. The operation was continued. A large carcinoma of the stomach with retroperitoneal extension was found and a biopsy specimen obtained. The patient recovered from the apparent cardiac arrest, but died two weeks later from his advanced cancer.

The second episode occurred in a 67 year old physician who had successfully undergone subtotal gastrectomy and cholocystectomy under pontocaine-dextrose continuous spinal anesthesia and pentothal, 2 per cent, supplementary anesthesia. The surgical dressings had been applied. The trachea was being

aspirated with a suction catheter when the pulse suddenly disappeared and the patient quickly became a mottled cyanotic color. An already prepared sterile set containing syringe, needles, and solutions was opened and 1 cc. of epinephrine, 1 to 1,000, and 3 cc. of procaine, 1 per cent, were injected through the fourth left interspace into the heart. The needle was left in place for a few seconds. It stayed perfectly still and then began to move as the heart suddenly took up its regular rhythm. The heart rate was 60 per minute at first and then increased to 120 per minute. This patient in his first few postoperative days showed no unusual effect from the cardiac arrest.

We still average 2 cases of cardiac arrest each year. The total now is 15. All hearts have been revived. Seven patients survived the complication and 1 patient appeared to recover but died on the second postoperative day of a coronary occlusion. Our survival rate at the present time is 46 per cent.

CONCLUSIONS

Cardiac arrest is an uncommon complication of a surgical operation. It is, however, a recognizable one, but requires acute awareness at all times by surgeon and anesthetist.

The heart can be started again in practically all cases that are true cardiac arrests, but probably three and one-half minutes is the time limit available to restore heart action, and restorations beyond that time limit leave patients with irreparable cerebral damage.

Only organized teamwork, planned procedures, and readily available instruments *and drugs make it possible to accomplish what must be done in three* and one-half minutes to retain the patient's mentality.

These cases will continue to occur. We must look on every patient who does have cardiac arrest as one who can literally and dramatically have his or her life saved if we can drill and train our operating room staffs and ourselves to do it.

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MISCELLANEOUS

SURGERY OF MÉNIÈRE'S DISEASE

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So many methods have been advocated for the treatment of Ménière's disease during the past decade that a review of the literature leaves one in a somewhat confused state of mind as to the most satisfactory way to manage such cases. It is quite natural that such a situation should exist, for the etiology of this condition is unknown and it has been only recently that the pathology has been demonstrated. Nevertheless, progress has been made and at the present time the management of the patient afflicted with Ménière's disease is better stabilized than at any other period in recent years. The majority of these patients respond favorably to medical treatment. Some patients, however, either are not benefited by such a conservative form of therapy or it is impractical to employ such a regimen because of the patient's occupation. In such instances surgical intervention must be relied upon to relieve them of their attacks of vertigo.

TYPES OF OPERATION

The surgical management of Ménière's disease has received considerable attention from neurosurgeons and otologists during the past decade. As a result, there are now a number of operations which may be employed to alleviate the intractable vertigo and disability which persist when medical treatment has failed. All but two are fundamentally alike in that their intent is to disrupt the flow of neurogenic impulses between the vestibular end organs and the vestibular nuclei. Technically, they differ either in their point of attack or the means by which the interruption is accomplished.

The majority of these operations have the labyrinth as their point of attack and effect the desired interruption of the vestibular pathway by destruction of the vestibular end organs. The way in which the destruction is accomplished varies with the procedure. Thus, absolute alcohol may be infiltrated into the perilabyrinthine fluid through the tympanic membrane by way of the oval window as advocated by Wright[10] or, as employed by Mollison,[6] through a fistula in the horizontal semicircular canal Cawthorne[1] avulses the membranous semicircular canal through a fistula in the bony horizontal semicircular canal. An electrocoagulating current may be utilized to effect destruction of the vestibular end organs through a fistula in either the horizontal semicircular canal as practiced by Day,[3] or the superior semicircular canal as advocated by Putnam.[9] Lempert[4] has described a technic in which destruction of the vestibular end organs and the organ of Corti is accomplished by fibrosis as a result of removing the footplate of the stapes and destroying the round window.

Portmann[8] and Passe[7] have devised operations which attempt to stabilize the

Originally published in Surgical Clinics of North America, 31.929–935 (June) 1951.

intralabyrinthine hydrodynamics to effect relief from the intractable vertigo due to Ménière's disease which has failed to respond satisfactorily to medical therapy. Portmann's operation is said to accomplish this through surgical attack upon the endolymphatic sac. Passe excises the stellate ganglion of the cervical sympathetic chain and ligates the vertebral artery to effect the stabilization. To the best of my knowledge, these operations are unique in that they are the only surgical procedures available today which make any attempt to rectify the hydrops of the labyrinth which is now known to be the pathologic condition of Ménière's disease.

While otologists have been largely responsible for the foregoing procedures, the neurosurgeons have perfected an operation utilizing another point of attack to disrupt the flow of neurogenic impulses between the vestibular end organs and the vestibular nuclei. Dandy[2] employed an intracranial approach to disrupt effectively the nerve pathway between the vestibular end organs and the vestibular nuclei by sectioning the eighth nerve just after its emergence from the internal auditory meatus. McKenzie[3] improved the operation by confining the section of the eighth nerve to the vestibular component, thus permitting the preoperative hearing level to be maintained in the majority of instances. This latter procedure was adopted by Dandy and is now considered by many neurosurgeons to be the operation of choice for the surgical treatment of Ménière's disease.

Ideally, the surgical management of Ménière's disease should effectively relieve the patient of the vertiginous attacks and the tinnitus without affecting the hearing. This latter is a debatable point when the disease is thought to be unilateral and the hearing of the affected ear has deteriorated to such an extent that it is no longer serviceable and, as is frequently the case, distorted. In such instances the preservation of a distorted remnant of hearing is undesirable particularly if the hearing in the opposite ear is comparatively good. Since it has been estimated, however, that approximately 10 per cent of the cases of Ménière's disease exhibit bilateral involvement it may be inadvisable to destroy the remaining cochlear function in the more involved ear when the hearing bilaterally is poor unless the symptoms can definitely be ascribed to the ear with the greater hearing loss.

The primary purpose of these procedures has been to prevent the acute episodes of vertigo. The available data tend to indicate that of the various operations that have been devised this is most consistently accomplished by resection of the eighth nerve and electrocoagulation or avulsion of the membranous horizontal semicircular canal in order to effect destruction of the vestibular end organ.

RESECTION OF THE EIGHTH NERVE

The most popular surgical procedure in this country, with the possible exception of the past couple of years, has been resection of the eighth nerve. When the resection has been confined to the vestibular component of the nerve, the results obtained more closely approximate the ideal than those following any other surgical procedure that has been established for the surgical treatment of patients with Ménière's disease.

Intracranial section of the eighth nerve has been employed at the Lahey Clinic on 91 patients during a thirteen year period for the relief of the intractable vertigo due to Ménière's disease. Resection of the eighth nerve, whether the nerve is completely or partially divided, is a major surgical procedure, but one that is relatively safe when performed by experienced neurosurgeons. There were 2 deaths in this series, 1 from ependymitis and the other by suicide on the sixth postoperative day. The latter patient was making an uneventful convalescence following operation and no cause could be determined for his act.

Total section of the eighth nerve was employed for 25 patients of this series. The vertigo was completely relieved in 16 and remained unchanged in 4 of these patients. Five patients could not be traced. In the remaining 66 patients resection of the eighth nerve was confined to the vestibular component. Forty-six of these 66 patients were completely relieved of their acute vertiginous attacks, while 5 noted no improvement. Thirteen patients could not be traced. In general, it may be said that the hearing of those patients subjected to differential section of the eighth nerve remained essentially unchanged as compared to the preoperative subjective loss of hearing. The effect upon the tinnitus was variable, but as a rule this symptom was not benefited by either total or partial section of the eighth nerve, although postoperatively those patients who had been relieved of their attacks of vertigo often found the tinnitus was no longer as annoying as before operation.

The incidence of postoperative complications in this series was small. Temporary paresis of the facial nerve occurred in only 2 patients, secondary infection of the wound occurred in one instance and only 1 of 2 fatalities previously mentioned could be directly attributed to the operation. In another patient a cerebrospinal fluid leak developed after operation which promptly ceased following revision of the dural and scalp wound. The average duration of hospitalization for all patients in this series was twenty days. It must be recognized, however, that a considerable number of these patients were in the hospital several days before operation for the purpose of special investigation to rule out the presence of an intracranial neoplasm as the cause of their symptoms Furthermore, as experience was gained, the average period of hospitalization deemed necessary gradually decreased to such an extent that during the latter years the average hospital stay was two weeks. The period of economic incapacitation which patients subjected to this operation experience is apparently of considerable duration. The average interval before the patient returned to work following discharge from the hospital was eighty-one days for a representative number of the patients in this series from whom such information was obtained. Sequelae of the operation appeared in a moderate number of the patients and were described as weakness, transient periods of postural giddiness and pain, numbness or a feeling of discomfort in the operative area.

EXCISION OF THE STELLATE GANGLION AND LIGATION OF THE VERTEBRAL ARTERY

During the past two years excision of the stellate ganglion of the cervical sympathetic chain and ligation of the vertebral artery, as described by Passe in England, have been employed by the neurosurgeons of the Lahey Clinic in an

effort to relieve the intractable vertigo of Ménière's disease in 3 patients. This operation is performed on the same side as the ear which exhibits the greater loss of hearing and, while theoretically simple, presents technical pitfalls which may prove troublesome. Two of the 3 patients on whom this procedure was employed obtained satisfactory relief from their acute episodes of vertigo, while 1 did not. The effect upon the hearing has not as yet been adequately determined. One patient stated that she had been able to hear over the telephone with the ear on the operated side, but audiometric examination of the hearing several months after operation revealed a total loss of hearing in this ear. Postoperatively all 3 patients have presented a Horner's syndrome on the operated side which they have found annoying to some degree.

ELECTROCOAGULATION OR AVULSION OF THE MEMBRANOUS HORIZONTAL SEMICIRCULAR CANAL

In recent years otologists have been directing their attention to devising operations that would effectively relieve the patient of the acute attacks of vertigo characteristic of Ménière's disease and yet be simple in their performance and without danger to the life of the patient. As a result there are now two operations which satisfy these requirements. Electrocoagulation of the labyrinth, commonly known as the Day operation in honor of the otologist who perfected it, is exceedingly easy to perform and not only effectively eliminates the vertiginous attack but can be accomplished without danger by the experienced otologist. This operation consists of performing a partial simple mastoidectomy in order to expose the bony horizontal semicircular canal adequately and, thereafter, electrocoagulating the membranous horizontal semicircular canal and the end organs of the vestibular component of the eighth nerve in the vestibule through a fistula in the bony horizontal semicircular canal. Cawthorne has devised another surgical procedure which is identical with the Day operation in every respect with the exception that, instead of utilizing an electrocoagulating current to effect destruction of the vestibular end organs, the membranous horizontal semicircular canal and the contents of the vestibule are avulsed. Removal of these minute structures can be accomplished by small forceps while observing the fistula in the bony horizontal semicircular canal through a binocular loupe or dissecting microscope but is greatly facilitated by the use of medium-sized dental broach rather than a forceps.

These operations have been performed on a large number of individuals during the past several years without mortality and with practically universal beneficial results in regard to the vertiginous attacks. In all cases the hearing in the operated ear is totally destroyed and, therefore, these operations should be reserved for those patients whose hearing in the affected ear is no longer at a serviceable level. Since the majority of patients afflicted with Ménière's disease have hearing below the serviceable level in the affected ear, however, the fact that the hearing is totally destroyed in that ear is of minor importance. As a matter of fact, the destruction of the remaining hearing may be of benefit in that it relieves the patient of the distortion which is frequently noted in the reception of sound between the two ears. At the present time the popularity

of these two operations among otologists and neurosurgeons alike would indicate that they will soon supersede, if they have not already done so, intracranial section of the eighth nerve as the procedure of choice in the surgical management of Ménière's disease.

Electrocoagulation of the labyrinth has been employed for the surgical treatment of Ménière's disease in 20 patients by the otolaryngologic service of the Lahey Clinic. The vertigo has been completely relieved in all patients. The hearing in the operated ear, which in no instance had been at a serviceable level before operation, was totally lost in all patients. The tinnitus was completely relieved in 4 patients, improved markedly in 10, remained unchanged in 5 and became worse in 1 patient.

There have been no deaths in this series. The only postoperative complication has been temporary facial paresis which occurred in 2 patients following operation and completely disappeared in a short time. The average duration of hospitalization was nine days, the shortest period being six days and the longest thirteen days The majority of these patients have been able to return to work within one month following operation which is of considerable economic importance when compared with the much longer period of incapacitation following intracranial section of the eighth nerve. Sequelae of the operation, consisting of transient dizziness on sudden change of position, a sensation of dizziness when walking in the dark or a feeling that the head was foggy, occurred in about half of the cases. These symptoms disappeared within three months following the patient's discharge from the hospital.

Avulsion of the membranous semicircular canal and the contents of the vestibule, as advocated by Cawthorne, has been employed by the otolaryngologic department of the Lahey Clinic in 5 patients during the past year, with very satisfactory results. In each instance the vertigo was entirely relieved and definite improvement in the tinnitus was noted with but one exception. The hearing in the operated ear was totally lost in all 5 patients and no postoperative complications have occurred.

SUMMARY AND CONCLUSIONS

A number of operations have been developed for alleviating the intractable vertigo of Ménière's disease in those patients in whom medical therapy either has failed or the institution of such a regimen was impractical The primary purpose of these procedures has been the prevention of the acute episodes of vertigo. The available data tend to indicate that this is most consistently accomplished by resection of the eighth nerve and avulsion or electrocoagulation of the membranous horizontal semicircular canal

Ideally, the surgical management of Ménière's disease should effectively relieve the patient of the vertiginous attacks and tinnitus without affecting the hearing. The results obtained with differential section of the eighth nerve more closely approximate this ideal than those with any other proved method This procedure has been employed in a sufficient number of patients with determination of the hearing before and after operation to permit the conclusion that the preoperative hearing level may be retained in the majority of cases. It is

debatable, however, whether the hearing in the affected ear should be preserved when it is poor and that of the opposite ear relatively good. Under such circumstances the hearing is frequently distorted. Retention of such a distorted remnant of hearing is neither desired nor appreciated by the patient and the accomplishment of an operation designed to preserve it which requires a high degree of surgical skill would seem to be an unnecessary surgical exercise. Differential section probably should be reserved only for those patients whose hearing bilaterally is good or in whom the disease is thought to be bilateral.

Forty-four of the 91 patients on whom complete or partial division of the eighth nerve was performed at the Lahey Clinic had audiometric examinations before operation. The hearing in the affected ear was of a practical nature in only 13 of these 44 patients. Thus, it may be inferred that practical hearing is not present in the affected ear in the majority of cases in which the disease is thought to be unilateral. In such cases an easily executed procedure such as that of Cawthorne or Day is preferable to the technically more difficult operation in which the eighth nerve is divided.

There appears to be little choice between avulsion of the membranous horizontal semicircular canal as practiced by Cawthorne and the method advocated by Day in which the membranous horizontal semicircular canal and vestibule are electrocoagulated. Both procedures are extremely easy to perform as compared to intracranial section of the eighth nerve. They are as effective in alleviating the intractable vertigo of Ménière's disease as is resection of the eighth nerve. The possibility of postoperative facial paralysis, however, even though it may be temporary, is greater when an electrocoagulating current is used to destroy the vestibular end organs. The incidence of postoperative complications with either of these operations is insufficient to warrant discrimination between them. The available data indicate that the period of economic incapacitation which the patient experiences following either of these two surgical procedures is considerably less than that following intracranial section of the eighth nerve

Since these methods are as effective in relieving vertigo and the period of hospitalization and rehabilitation is definitely less, either of these operations for the surgical treatment of Ménière's disease is preferable to the technically more difficult operation of total or partial resection of the eighth nerve when the disease is believed to be unilateral and the hearing in the affected ear is poor.

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stroyed by trauma or disease. Surgical maneuvers medial to this point must be consummated with care.

The digastric groove, created by the posterior belly of the digastric muscle on the medial aspect of the tip of the mastoid process, is represented as a gently con-



Fig. 478. Level of facial nerve between horizontal semicircular canal and stylomastoid foramen.

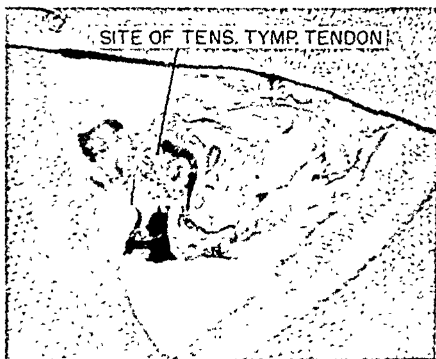


Fig. 479. Facial nerve exposed to show relationship to tendon of tensor tympani muscle.

cave ridge in the inferior portion of a mastoid cavity from which all tip cells have been removed and the plate of the sigmoid sinus clearly defined from the knee to the vicinity of the jugular bulb. The digastric ridge runs anterior and lateral

to the sigmoid sinus to blend with the skeletonized posterior bony wall of the external auditory canal. Where the digastric ridge and posterior bony canal wall meet marks the stylomastoid foramen and denotes the inferior level of the facial nerve (Fig. 477). Thus, the exact position of the vertical segment of the facial nerve may be determined by visually connecting the eminence of the horizontal semicircular canal with the point where the digastric ridge and osseous external auditory canal blend. Surgical procedures necessary to eradicate a pathologic process medial or lateral to this line of demarcation may be accomplished with-

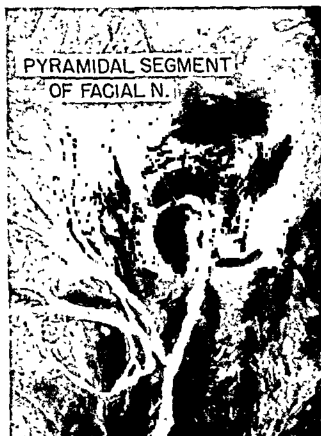


Fig 480. Pyramidal segment of facial nerve outlined to demonstrate proximity to postero-superior margin of tympanic cavity.

out fear of traumatizing the facial nerve if the line of demarcation is respected (Fig. 478).

The anterior extension of the intratympanic portion of the facial nerve is approximately represented by the point at which the tendon of the tensor tympani muscle is given off from the processus cochleariformis (Fig. 479). While not an exact surgical landmark, it is a reliable guide to the position of the nerve in this location during a radical mastoidectomy. In reality, the facial nerve runs medialward and slightly superior and anterior to this point to join the geniculate ganglion. For all practical purposes, however, the nerve is safe from surgical trauma while removing granulation tissue and necrotic bone from the tegmen tympani and expanding superior rim of the orifice of the Eustachian tube in this region so long as the cutting edge of a small curette is directed superior to the tendon of the tensor tympani muscle; furthermore, this latter structure is an invaluable

guide to exposure of the geniculate ganglion. Posteriorly, the intratympanic segment terminates at the ampullary end of the horizontal semicircular canal. At this point it is slightly superior and lateral to the capitulum of the stapes and lies against the inferior and medial aspect of the anterior end of the horizontal semicircular canal.

The pyramidal portion of the facial nerve lies between the intratympanic and vertical segments. It is in intimate relationship with the inferior surface of the horizontal semicircular canal, lying slightly medial to the prominence of the canal. If the nerve is removed from the Fallopian canal in its pyramidal course it gives the impression that it lies in a groove on the inferior aspect of the horizontal canal. In this area the facial nerve lies close to the superoposterior wall of the middle ear and is susceptible to injury through injudicious use of the curette when removing granulation tissue or the annulus in this area (Fig. 480).

This description of the surgical anatomy of the facial nerve is readily applicable to operations directed toward the mastoid process and tympanic cavity of the temporal bone. Cognizance of the relationship of the facial nerve to the landmarks described will permit such surgical procedures to be carried out without injury to the facial nerve and, when necessary, expedite exposure of the nerve at any point from the geniculate ganglion to the stylomastoid foramen. It must be emphasized, however, that merely a thorough knowledge of the surgical anatomy of the facial nerve is no substitute for adequate training and experience.

Neck and Face

Distal to the stylomastoid foramen, the facial nerve traverses the soft tissue of the neck and face to innervate the muscles for facial expression. In its facial dis-

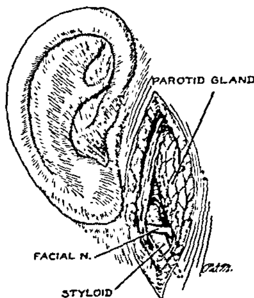


Fig. 481. Relationship of cervical trunk of facial nerve to styloid process.

tribution, injury to the nerve may occur as a result of deep lacerations of the face or during the course of operations upon the parotid or submaxillary glands, the temporomandibular joint and the soft tissue of the face for excision of tumors or scars. Since many otolaryngologists include such procedures in their field of

practice, any discussion of the surgical anatomy of the facial nerve would be incomplete without a description of the applied surgical anatomy of the nerve in this region.

In its course through the soft tissue of the face the facial nerve is closely associated with structures which are of aid in determining its location. While the relationship of these landmarks to the facial nerve is not as exact as within the temporal bone, it is sufficient to permit the experienced surgeon to locate and expose the facial nerve in order that unnecessary trauma to the nerve may be prevented or reparative procedures instituted. The first landmark to be encountered

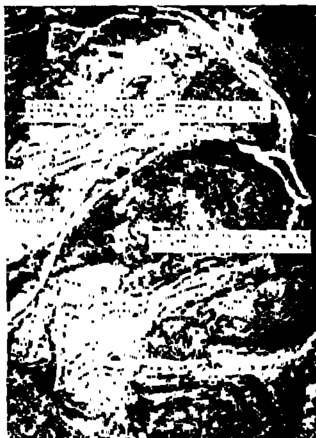


Fig. 482. Relationship of temporofacial division to anterior border of parotid gland and parotid duct.

after the facial nerve emerges from the skull is the styloid process Emerging from the stylomastoid foramen, the nerve is directed anteroinferiorly and somewhat laterally to enter the posterior border of the parotid gland, and in this location lies either on or just lateral to the styloid process (Fig. 481). Although it varies greatly in size, this structure is invariably present and is a reliable guide to the position of the cervical portion of the facial nerve.

The facial nerve is intimately related to the parotid gland. The parotid gland is essentially a bilobed structure with the larger superficial portion intimately connected to the smaller and deeper lying segment by an isthmus of moderate size and numerous smaller communications made up of connective, nerve and glandular tissues. Contrary to common impression, the facial nerve does not penetrate the substance of the gland but lies between the larger superficial lobe and the

smaller deep lobe. This has been conclusively demonstrated by McCormack, Cauldwell and Anson.[3] Shortly after entering the parotid gland, the cervical trunk of the facial nerve regularly divides into two principal divisions, the temporofacial and cervicofacial portions, which lie on either side of the isthmus. The point at which this division occurs is of little surgical significance but is roughly located medial to the anterior border of the lobule of the external ear or two-thirds of the distance from the angle of the mandible to the temporomandibular joint and just posterior and medial to the ramus of the mandible.

The temporofacial and cervicofacial divisions continue to run forward and further divide between the superficial and deep lobes of the gland to appear at its anterior border. The former is the larger and more important of the two divisions; its branches emerge from under cover of the superficial lobe at its anterior and superior margin in relationship to the zygomatic arch and parotid duct (Fig. 482). This latter structure is an important landmark with respect to the surgical anatomy of the facial nerve distal to the parotid gland, as the zygomatic or buccal branch of the facial nerve runs transversely across the face just above the parotid duct and often crosses it. The inferiorly directed cervicofacial division emerges at the lower pole of the parotid gland, from which point the mandibular branch may be found running along the body of the mandible or just inferior to it.

Although considerable anatomical variation with respect to the relationship of these landmarks to the facial nerve may exist, the deviation is not sufficient to prevent them from being of definite value when location of the cervical trunk or the principal branches of the facial nerve distal to the stylomastoid foramen is necessary. The utilization of these landmarks will enable an experienced surgeon to "pick up" the facial nerve, either proximal or distal to the parotid gland, with a minimum of difficulty and will facilitate exposure of the nerve in its course between the lobes of the parotid gland.

METHODS OF EXPOSURE

Exposure in the Temporal Bone

Exploration of the facial nerve is indicated when facial palsy supervenes immediately following an apparently uneventful mastoidectomy. For this purpose the nerve may be "picked up" at several points in its course through the temporal bone if the landmarks previously described are utilized to locate its position in the area in which exposure is desired. From this point the facial nerve can be further exposed to include all or any part of its vertical, pyramidal or intratympanic segments. It is a prerequisite, of course, that appropriate surgical eradication of the pathologic process within the mastoid or tympanic cavity has been accomplished The sole exception to this requirement is when decompression of the facial nerve is undertaken for Bell's palsy.

The facial nerve in its vertical course through the mastoid is most easily "picked up" as it emerges from the stylomastoid foramen. The mastoid tip is removed in its entirety with gouge and mallet or rongeurs to the level of the digastric groove, which is then followed anteriorly to the posterior rim of the stylomastoid foramen. The periosteum and fibrous tissue of this area resembles a small inverted funnel with the spout corresponding to the vertical portion of the facial

nerve. The bone forming the posterior and lateral borders of the stylomastoid foramen, as well as that covering the immediately adjacent Fallopian canal, is shaved down to the thickness of paper with gouge and mallet or an electrically driven burr parallel to the vertical course of the facial nerve. Removal of the remaining thin plate of bone exposes the nerve. This is most readily accomplished by inserting the tip of a small curette or dental pick underneath the edge of this thinned plate of bone at the stylomastoid foramen and lifting the instrument away from the facial nerve so as to remove the engaged portion of bone. Repetition of these maneuvers along the vertical course of the facial nerve will permit its exposure from the stylomastoid foramen to the horizontal semicircular canal (Fig. 483).



Fig. 483. Facial nerve exposed from stylomastoid foramen to horizontal semicircular canal after removal of mastoid tip.

The facial nerve may be exposed also in the stylomastoid foramen and the inferior end of the Fallopian canal from within the mastoid cavity. The digastric ridge is the keynote to success with this approach to the facial nerve. The anatomical tip of the mastoid process is not removed in this procedure, but it does necessitate careful removal of the cellular structure of the tip and exposure of the plate of the sigmoid sinus in the inferior aspect of the mastoid cavity in order that the digastric ridge may be sharply defined. The point at which the ridge meets the skeletonized posterior wall of the external auditory canal marks the inferior end of the Fallopian canal and stylomastoid foramen. The facial nerve may be exposed at this point from within the cavity of the mastoid by gentle removal of thin shavings of bone parallel to the vertical course of the nerve with a medium sized sharp curette or electric burr until the neurilemmal sheath is observed. Exposure of the facial nerve is then obtained by removing the overlying bone piecemeal with a small, sharp curette, the cutting edge of which is held parallel to the axis of the nerve (Fig. 484). This method of approaching the facial nerve, while more difficult than that described above, is particularly adapt-

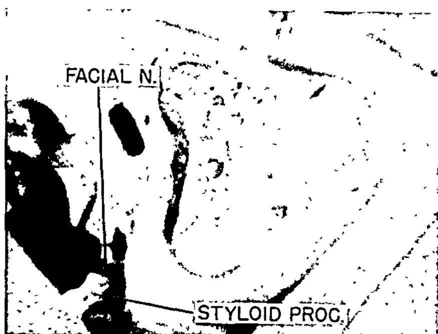


Fig. 484. Facial nerve exposed from stylomastoid foramen to horizontal semicircular canal without removal of mastoid tip.



Fig. 485. Facial nerve exposed from stylomastoid foramen to vicinity of geniculate ganglion.

able to those cases of Bell's palsy in which decompression of the facial nerve is deemed advisable, since its employment causes a minimum of postoperative discomfort and disability.

Exposure of the pyramidal segment of the facial nerve may be accomplished by using the horizontal semicircular canal as a guide. Careful removal of the bone lying immediately anterior and inferior to the horizontal semicircular canal in the manner previously described will expose the nerve in this area. While a radical mastoidectomy is not absolutely necessary to permit adequate exposure of the pyramidal portion of the facial nerve in a well pneumatized temporal bone if the incus is removed, it is almost invariably a prerequisite in the event a nerve graft must be utilized to repair a defect of the nerve in this region (Fig. 484).

The intratympanic segment of the facial nerve is accessible after a radical mastoidectomy has been performed. This is the only portion of the facial nerve that is not buried deeply within the temporal bone. It may be recognized as a rounded elevation running horizontally across the upper limit of the tympanic cavity immediately inferior to the anterior end of the horizontal semicircular canal and surgical dome of the vestibule. The nerve in this location is covered by extremely thin and brittle bone, which facilitates its removal. Exposure is best effected by engaging the cutting edge of a small curette at a point on its greatest convexity and, with sufficient pressure at a tangential plane, fracturing and removing a small fragment of bone. From this point the nerve may be completely uncovered by removing its bony covering piecemeal with the point of a small curette or dental searcher (Fig. 485).

Exposure in the Neck and Face

The facial nerve may be isolated at several points distal to the stylomastoid foramen. Using this point as a focus for further exposure, the nerve may then be traced throughout its course in the soft tissue of the neck and face. The simplest way to accomplish this is to locate the facial nerve as it emerges from the stylomastoid foramen by removing the tip of the mastoid process as described in an earlier part of this paper. Thereafter, the cervical trunk of the facial nerve may be traced forward through the parotid gland and into its facial arborization by sharp and blunt dissection. A nerve stimulator may be utilized to identify and facilitate the exposure of the nerve as the dissection is carried forward.

An alternative method of locating the facial nerve proximal to the pes anserinus is that employed by Maxwell.[2] An incision is made through the skin and subcutaneous tissue just anterior to the tragus, beginning just above its upper margin and extending downward several centimeters below the inferior border of the lobule of the ear. Closely hugging the anterior wall of the external auditory canal, the posterior surface of the parotid gland is freed by blunt dissection until the base of the styloid process is located. This is the keynote to this approach, since the styloid process maintains a close relationship to the facial nerve as it courses forward from the stylomastoid foramen The dissection is carried along the lateral surface of the styloid process until the cervical trunk of the facial nerve is located (see Fig. 481). Once isolated, further exposure is accomplished as described in the previous paragraph.

The inframandibular branch of the facial nerve may be employed to locate the

pes anserinus when operating on the parotid gland. Sistrunk[4] located this branch as it runs beneath the platysma muscle 1.5 cm. inferior to the angle of the mandible through an incision which began at the tip of the mastoid and curved forward and anteriorly to end just posterior to the superior cornu of the thyroid cartilage. An incision so situated lies approximately 2 cm. posterior and inferior to the angle of the mandible. The inframandibular branch of the facial nerve may be exposed with minimal trauma through such an incision if a faradic stimulator is utilized to facilitate its identification at exposure. The nerve is dissected up through the substance of the parotid gland to the point at which the cervical trunk of the facial nerve divides into the temporofacial and cervicofacial divisions.

Adson[1] combined this approach with one of his own to expose the facial nerve within the parotid gland. A vertical incision just anterior to the ear, beginning

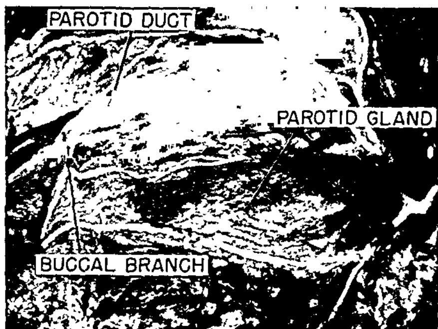


Fig. 486. Relationship of buccal branch of facial nerve to parotid duct.

at the zygoma, is curved around the lobule to join Sistrunk's incision. After the skin and subcutaneous tissue are reflected from the superficial lobe of the parotid gland, the superior branches of the facial nerve are located as they cross the zygoma. These are dissected through the gland to locate the pes anserinus. The cervicofacial division is then exposed, following the technique of Sistrunk. In this way the superficial lobe of the parotid gland may be elevated from the underlying facial nerve and removed without permanent injury to the nerve.

The buccal branch of the facial nerve distal to the parotid gland maintains a close relationship with the parotid duct. If the anterior border of the gland is exposed through an incision just anterior to the ear, beginning at the temporomandibular joint and curving slightly anteriorly to terminate just below the angle of the mandible, this branch of the facial nerve may be located, as it runs slightly superior and parallel to the duct in the area just anterior to the border of the gland (Fig. 486). From this point the anterior border of the superficial lobe of the parotid gland may be elevated superiorly and inferiorly to expose the remain-

ing branches of the facial nerve. Keeping the branches of the nerve in constant view by retracting the superficial lobe of the gland, the dissection is carried posteriorly until the converging branches unite, to be continued proximalward as the cervical trunk. Transection of the isthmus of the gland parallel to the facial nerve permits removal of the superficial lobe of the parotid gland and visualization of the branches of the facial nerve throughout their course from the distal end of the cervical segment to the smaller branches in its facial distribution.

SUMMARY

The surgical anatomy of the facial nerve within the temporal bone, neck and face has been described. Identification and application of the anatomical landmarks specified will accurately designate the course of the nerve within the temporal bone and, to a lesser degree, that of the facial nerve in the neck and face.

Methods for exposing the facial nerve in several locations have been given. Thorough familiarity with these methods will permit exposure of the facial nerve at any point from the geniculate ganglion to its distal branches and enable the surgeon to utilize the approach best adapted to the individual case.

While a thorough knowledge of the surgical anatomy of the facial nerve will permit the surgeon to visualize mentally its location, it does not necessarily follow that he is capable of its exposure. Adequate training and experience in surgery are prerequisites for such a surgical procedure and, in addition, the surgeon must be equipped mentally and physically to perform such surgery. The surgeon operating on such patients must be thoroughly conversant with the anatomy of this region and be blessed with an infinite amount of patience and perseverance.

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ANTICOAGULANT TREATMENT OF POSTOPERATIVE VENOUS THROMBOSIS AND PULMONARY EMBOLISM

JAMES A. EVANS AND JOHN F. DEE

Anticoagulant treatment is winning for itself a firm place in the armamentarium against postoperative venous thrombosis and pulmonary embolism. This has been accomplished by the sheer weight of accumulating statistics from various clinics, both in this country and in Sweden.[1-22] Since April, 1941, when Dicumarol first became available, the drug has provided the predominant method of therapy at the Lahey Clinic. In the majority of cases a combination of heparin and Dicumarol has been used. During the first four years heparin was given by continuous intravenous drip to cover the latent period of Dicumarol. For the past five years deep injections of heparin in menstruum* have been given subcutaneously.

In a series of 184 cases, occurring from 1942–1946, venous ligation was also performed in 10 cases. The two systems of treatment, venous ligation and administration of heparin in menstruums, should not be considered rival methods but rather complementary to each other. Our confidence in the efficacy of anticoagulant therapy, however, has grown through these five years to such an extent that the indications for venous ligation have dwindled to the following conditions. hemorrhagic disease; severe liver disease; second-stage operation; ambulatory phlebothrombosis with pulmonary embolism (Homans); resistance to both heparin and Dicumarol; recurrence of benign embolism after supposedly adequate treatment; prophylactic ligation in patients over sixty years of age for expected bleeders (prostatic resection), and prophylactic ligation in patients over sixty who are debilitated from cancer or other causes (Miles resection). Ligation in elderly patients who are debilitated from cancer or other causes is regarded as only a relative indication to be used at the surgeon's judgment, because in the Lahey Clinic it would add the insurmountable surgical burden of about three or four thousand ligations a year. Therefore, prophylactic exercises, early ambulation and Dicumarol prophylactically are preferred on the fourth day after operation.

Although it must be admitted that the vagaries of Dicumarol resistance and sensitivity in different patients and the pitfalls of accurate prothrombin estimations should limit its use to the experienced and wary clinician equipped with a very reliable laboratory, it is believed that the advent of heparin in menstruums will popularize anticoagulant therapy as a safe and reliable method of treatment.

Revision of article originally published in the New England Journal of Medicine, 238:1–5 (Jan. 1) 1948.

* Kindly supplied by W. R. Warner and Company, Inc., New York City and in part by Roche-Organon, Nutley, New Jersey.

This will occur when the menstruum is more widely available and the cost of this product has dropped.

RULES FOR ANTICOAGULANT THERAPY

After eight years' experience with anticoagulant therapy we have evolved the following set of rules—applicable to all patients kept lying in bed—for instruction to the staff:

As a precaution against thrombosis and embolism, the patient should be instructed to wiggle the toes and feet one thousand times daily, including pressing the soles of the feet against the foot of bed if possible.

If the patient has varicose veins, elastic bandages are to be used twenty-four hours a day until he is ambulatory.

The patient should be asked daily on rounds if there is pain in the calf, and inspected for soreness in the calf and for Homans' sign, especially if unexplained fever is present.

A stamp has been provided for history charts, entitled "History of Venous Thrombosis or Pulmonary Embolism." This should be stamped on every history and filled in. If a patient with such a history comes to surgery, he should receive postoperative anticoagulant therapy after consultation between the surgical and medical departments.

Such treatment should be started routinely four days after operation, five days after galbladder surgery or on a later day if deemed advisable by the surgeon. Dicumarol only is necessary for such prophylactic therapy and, therefore, only the prothrombin time should be determined.

No anticoagulant therapy is given to patients with severe liver disease or hemorrhagic diseases or to those who are soon to undergo a second operation.

The routine after carotid-artery ligation, immediately after return from the operating room, includes 100 mg. of heparin in menstruum without a vasoconstrictor, 100 mg. of heparin in menstruum with a vasoconstrictor and 200 mg. of heparin in menstruum with a vasoconstrictor if the patient weighs over 150 pounds. Only one such injection, deep subcutaneously, should be given, and no coagulation-time control is necessary.

For routine anticoagulant therapy, the prothrombin and coagulation times should be controlled.

Heparin in menstruum—100 mg.—without a vasoconstrictor and heparin in menstruum—100 mg.—with a vasoconstrictor should be injected deep subcutaneously; if the patient weighs over 150 pounds, 200 mg. with a vasoconstrictor should be injected deep in the subcutaneous tissues.

Dicumarol (200 mg.) should be given—300 mg. if the patient weighs over 150 pounds.

Daily morning determinations of the coagulation time and prothrombin percentage are necessary.

A daily maintenance dose of 50 to 100 mg. of Dicumarol should be administered to keep the prothrombin between 50 and 60 per cent.

No Dicumarol should be given until the morning prothrombin time is known for that day.

If the patient proves refractory to Dicumarol, the same dosage of heparin in

menstruum should be given until the coagulation time comes back to normal, usually every third day.

Heparin in menstruum should be discontinued when the prothrombin drops to 60 per cent, and coagulation-time determinations should be stopped.

For any bleeding, the prothrombin time, as well as the coagulation time if the patient is also receiving heparin, should be determined, and 60 mg. of vitamin K given intravenously. This procedure is repeated every six hours until the prothrombin time is normal, which takes from eight to forty-eight hours. Fresh-blood transfusions should be given if indicated to give undeteriorated prothrombin. A transfusion is needed to counteract the effect of the heparin, and vitamin K to

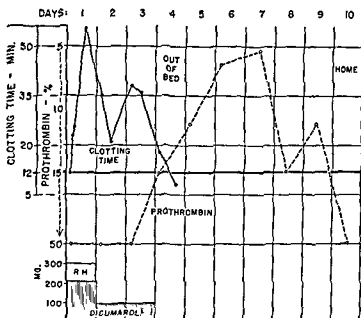


Fig. 487. Course in a typical case successfully treated with anticoagulants. Any part of the coagulation time above the heavy black horizontal line represents the anticoagulant effect of heparin; any part of the prothrombin line above the same black line represents what is considered a fairly safe antithrombotic effect of Dicumarol—namely, a prothrombin level below 65 per cent. We strive to keep the prothrombin percentage between 40 and 50.

counteract that of Dicumarol. Ice bags should be applied to the heparin in menstruum deposit.

The patient is to be ambulatory when the temperature has returned to normal and local signs of venous thrombosis (except swelling) have disappeared, if the surgical department permits and if the anticoagulant effect is present.

Paravertebral sympathetic blocks should be employed if signs of reflex arterial spasm (swelling, white limb, absent pulses and pain) are present.

A heat cradle should be applied to the legs.

For pulmonary embolism, 0.06 to 0.12 gm. of papaverine should immediately be injected intravenously.

Figure 487 illustrates a typical successfully treated case. A majority of patients in this series were allowed out of bed within ten days of the beginning of therapy.

ADVANTAGES OF ANTICOAGULATION

The fact that anticoagulant therapy can do nothing to prevent the fragile red clot of phlebothrombosis from breaking off is the chief argument advanced by

the opponents of this method of treatment. Three facts assure protection against this hazard: Loewe[23] has shown that heparin actually causes this "sludge" type of clot to disappear in animal experiments in vivo (whether Dicumarol actually has a similar effect has never, to our knowledge, been proved); statistics have accumulated to prove that the actual subsequent pulmonary emboli to be expected statistically do not occur; and metastasis of the bland phlebothrombosis clot results from very fresh, unrecognized foci and rarely from clinically recognizable foci. Such dangerous new areas of phlebothrombosis are prevented from forming.

Death from pulmonary embolism is also made less likely by the prevention of propagation of a thrombus already present in the pulmonary arterial tree. This fact leads to the rule of permitting patients to be out of bed only when a good anticoagulant effect obtains.

The advantages of anticoagulation are as follows: avoidance of another operation, usually on a very sick patient; avoidance of danger of swelling in some cases, avoidance of danger of arterial thrombosis and gangrene in arteriosclerotic patients; inhibition of spreading thrombotic disease in systemic veins and in pulmonary arteries if a benign embolism has already occurred; no hesitation to institution of anticoagulant therapy in very doubtful cases; statistical proof from several clinics that anticoagulation prevents subsequent fatal pulmonary embolism, and decreased incidence of postphlebitic venous stasis and ulcer (Bauer[13]).

RESULTS

There were 184 cases of postoperative venous thrombosis with or without pulmonary embolism during the five years 1942–1946. Sixty-three patients received

Table 1. Incidence of Venous Thrombosis and Pulmonary Embolism among 56,000 Major Surgical Operations (1942–1946)

POSTOPERATIVE COMPLICATION	NO OF CASES
Venous thrombosis without embolism (treated)	123
Venous thrombosis with warning pulmonary embolism (treated)	61
Sudden or unrecognized fatal pulmonary embolism (not treated)	54
Total	238 (0.42%)

heparin intravenously, 2 of them by the intermittent, Swedish method. Fifty-five received heparin in menstruum. One to five injections of heparin in menstruum were necessary according to the patient's refractoriness to Dicumarol. Three patients received heparin only. Sixty-three patients received Dicumarol only. Twenty-seven patients, or 15 per cent, were considered refractory to Dicumarol. All such patients now receive heparin in menstruum to keep them in control. A patient was considered refractory when the prothrombin level did not fall below 65 per cent despite ordinarily adequate doses. Fortunately, only 1 death occurred among the refractory patients, but this is not considered an excuse to administer Dicumarol without adequate control of dosage by determination of the daily prothrombin levels.

Sixty-one of the 184 patients, or 33 per cent, had a warning benign pulmonary embolism (Table 1). To the 184 cases must be added 54 patients who had post-

operative pulmonary embolism and who died untreated, because such deaths either occurred suddenly or were unrecognized as thrombosis with embolism. This makes a total of 238 cases of thromboembolic disease in five years, or an incidence of 0.42 per cent among approximately 56,000 major surgical operations performed at the New England Deaconess and New England Baptist hospitals by the surgeons of the Lahey Clinic. This low incidence was due to the assiduous care of the nursing staffs of these two hospitals in seeing that the patients carried out proper prophylactic exercises. That such precautions were largely responsible for the results is strongly suggested by the fact that in three winter months at the start of our campaign against pulmonary embolism the incidence in a hospital where the staff had not yet received instructions to carry out these exercises was three and a half times that in another hospital, where the exercises were practiced, the number of cases being 7 and 2 respectively.

There were 6 fatal cases in the series of 184 patients. Two were postoperative chemical deaths. One patient early in the series died of hemorrhage from Dicumarol poisoning, because at that time the value of the rule never to give the daily dose of Dicumarol until that morning's prothrombin time is known was not appreciated. This leaves 3 fatal cases of thromboembolic disease. One patient received inadequate doses of Dicumarol, and a prothrombin level within the therapeutic range was never obtained, he was also given a transfusion, which destroyed any slight effect the Dicumarol might have had, and he died of a second pulmonary embolism a few hours later. Another patient died a few hours after a single pulmonary embolism, in spite of one dose each of heparin in menstruum and Dicumarol given when he was *in extremis.* He would not have been saved by venous ligation, unless it had been done prophylactically at the time of operation. The cause of death in the third case was declared sepsis by the pathologist. The patient had received adequate anticoagulant control throughout, but died of a septic infarct with pyopneumothorax and septic peritonitis.

It has long been recognized that a warning benign pulmonary embolism increases greatly the chance of a subsequent fatal embolism. In all 3 fatal cases a warning embolism had occurred. There were 61 cases in the series in which a warning was given by a benign infarct to the lung—a mortality of 5 per cent in this category, or 1.6 per cent for the entire series In the past two years, since the use of heparin in menstruum as well as Dicumarol and with better control of the anticoagulant effect by continued administration of heparin subcutaneously until a good Dicumarol effect is obtained, only 1 death has occurred—that of the patient with sepsis mentioned above.

There were benign recurrences of pulmonary embolism in 2 of the 61 patients who had warning benign pulmonary infarcts. One of these occurred after only four days and after treatment had been abandoned. Further heparin in menstruum combined with Dicumarol was given, with recovery. In the other patient Dicumarol had also been stopped when a subsequent embolism occurred. Bilateral ligation was then performed, with recovery. The prothrombin level at the time of infarct was not stated in the records of either patient.

There was no occurrence of either fatal or benign pulmonary infarct among the 123 patients who never had a warning infarct. This fact points up the danger to the patient who has had a warning embolism.

COMPLICATIONS

Bleeding was recorded in 12 cases (Table 2). It was of a serious nature, requiring transfusions or vitamin K, or both, in 5. Two cases required heroic treatment with repeated doses of 60 mg. of vitamin K and transfusions totaling as much as 2750 cc. of blood. There was 1 fatal case of bleeding into the wound early in the series before vitamin K was known to be an antidote for Dicumarol.

Vitamin K has made Dicumarol much safer to use. For prothrombin levels as low as 20 per cent, we have often given booster doses of 40 mg. of vitamin K (either Hiquinone or Synkavite), bringing the prothrombin level to a safer therapeutic range but not losing the anticoagulant effect. For serious bleeding we recommend 60 mg. intravenously, repeated two or three times a day, together with transfusions of fresh citrated blood. Bank blood is too low in prothrombin content but may be used for blood replacement. Protamine is the antidote for heparin.

Table 2. Complications of Anticoagulant Therapy

COMPLICATION	NO. OF CASES
[illegible] recovery	4
[illegible]	1
[illegible]	1
Bleeding from various sources not requiring treatment	6
Total	12

There have been a few hematomas at the site of injection of heparin in various menstruums in over 200 patients receiving hundreds of injections.

DISCUSSION

There still remains the problem of the sudden deaths from pulmonary embolism occurring before there is an opportunity to treat the patient. The results reported above give us great confidence in trusting anticoagulant therapy in the recognized cases of postoperative venous thrombosis. During the five years under study 59 patients died of pulmonary embolism; in 27 the diagnosis was proved at autopsy, 4 cases in this category occurring in medical patients. This situation must be met by eternal watchfulness of the postoperative and bedridden patient. Here, too, lies a field for more prophylactic ligations as done by Allen, Linton and Donaldson[24] in the debilitated patient over 60 years of age. Dicumarol should be used prophylactically more often, and we give this treatment routinely to patients with a history of thrombophlebitis or embolism following a previous operation or childbirth. Our results in the prophylactic use of Dicumarol will be the subject of a future report.

In addition to the routine daily examination of legs postoperatively, more attention must be paid to the temperature and pulse chart. An analysis of 52 cases of death from pulmonary embolism revealed that 85 per cent of the patients gave warning signs of rise in temperature or pulse, or both, or had varicose veins or a previous history of thrombotic disease (Table 3).[8]

That our efforts to prevent death from postoperative pulmonary embolism have not been in vain is shown in Figure 488. The mortality was cut to one fifth in 1947, our best year. The rise during the last two years shows the need of guarding against complacency and of still greater alertness on the part of all services to

Table 3. Warning Signs in 52 Fatal Cases of Pulmonary Embolism (1940–1945)

TYPE OF CASE	NO. OF CASES	WARNING SIGNS* NO. OF CASES
Death in 1 hour	22	16
Death in 2–24 hours	20	18
Death 1–24 days after first benign pulmonary embolism	10	10

* Warning signs included fever and tachycardia, varicose veins, previous history of thrombosis or embolism and premonitory pulmonary embolism.

attain what should no longer be considered an impossibility: a deathless year from pulmonary embolism. More prophylaxis by both venous ligation and anticoagulation seems to be the answer. The former is impractical in a large surgical service except in cases considered most susceptible. Prophylactic exercises, band-

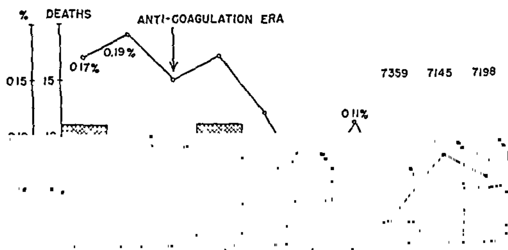


Fig. 488. Mortality from postoperative pulmonary embolism. Note the decreasing rate after institution of anticoagulant therapy in 1942, together with institution of prophylactic exercises and increased watchfulness for signs of thromboembolic disease.

aging of varicose veins, early ambulation and anticoagulant therapy must be used for the larger majority of patients considered to be susceptible. Anticoagulant therapy is adequate for postoperative patients who already have developed thrombosis with or without pulmonary embolism.

SUMMARY

Anticoagulant treatment by heparin or heparin in menstruum in combination with Dicumarol offers a safe, practical method to prevent postoperative death from pulmonary embolism.

The recent introduction of heparin in menstruum injected subcutaneously has

greatly simplified anticoagulation. This therapy has the added advantage of producing an anticoagulative effect that can easily be kept up as long as necessary in the Dicumarol-refractory patient.

Of 184 patients with postoperative venous thrombosis with or without warning pulmonary embolism, 3 patients died of thromboembolic disease—an incidence of 1.6 per cent. These 3 deaths occurred in the particularly dangerous group of cases in which the patients had already suffered one pulmonary embolism, and represented a mortality of only 5 per cent in this category. On analysis, none of these 3 cases presented a clear-cut argument against the efficacy of anticoagulation therapy.

Since 85 per cent of patients with fatal pulmonary emboli give warning signs, usually a low temperature and tachycardia or a history of previous thromboembolic disease, or have varicose veins, a plea is made for better prophylaxis. This can be accomplished by leg exercises, bandaging of limbs, early ambulation, prophylactic ligation in debilitated patients over 60 years of age or the administration of Dicumarol on the fourth day after operation.

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SURGICAL MANAGEMENT OF ARTERIOVENOUS ANEURYSMS

HERBERT D. ADAMS

I. TRAUMATIC, FALSE AND ARTERIOVENOUS ANEURYSMS

Among the most serious injuries of the thorax are those of the major arteries, the so-called false aneurysms and arteriovenous aneurysms, or a combination of both. Technically, the surgical management of some of the more proximal arterial injuries is undoubtedly one of the most hazardous and difficult operations in surgery. Those in the extremities distal enough so that a tourniquet can be used and a direct dissection done in a bloodless field are relatively simple. Those injuries located in the groin, the abdomen, the neck, shoulder and chest, however, require an entirely different approach and surgical management if the patients are to survive their operations. This is particularly true of the arterial injuries of the thorax, with its close anatomic relationships and difficulty of obtaining wide and easy exposure.

Penetrating wounds of the thorax, either major or minor, have the serious potentiality of an injury to one of the many arteries, both superficial and deeply located in the thorax. It is difficult to estimate the incidence of this type of injury since most of these wounds are undoubtedly immediately fatal. This is due to the fact that a tourniquet cannot be used and, likewise, adequate pressure control is rarely instantly available or possible. This type of injury, however, is certainly not always fatal because some of these patients reach hospitals at considerable distances for definitive treatment. The hemorrhage is at least temporarily controlled by infiltration of the surrounding muscles and tissues, with a resulting pulsating hematoma or false aneurysm.

The diagnosis is frequently missed because of the insignificance of the external wound and the lack of obvious extensive infiltration or hematoma, or visible or palpable pulsation. Many are not diagnosed until an episode of serious secondary hemorrhage occurs. It is absolutely essential that every wound in this region be examined specifically for evidence of arterial injury, especially by auscultation for the presence of a bruit. Because of the serious nature of the operation necessary to cure this type of injury, surgery should be withheld long enough to insure a reasonably certain diagnosis, ruling out bruits resulting from extrinsic infiltration and pressure on the artery, and also functional bruits. Operation should not be delayed long, however, in order to avoid serious secondary hemorrhages and pressure atrophy of nerves and muscles, with the associated great loss of function.

Revision of article entitled "Arterial Injuries of the Thorax" and published in the Journal of Thoracic Surgery 15 365–372 (Oct.) 1946, combined with "Congenital Arteriovenous and Cirsoid Aneurysms," published in Surgery, Gynecology and Obstetrics (June) 1951.

MANAGEMENT AND TREATMENT OF SPECIFIC ARTERIES

The Mammary and Intercostal Arteries

Injuries of the mammary and intercostal arteries are of two general types, (1) false aneurysms with *subpleural* hematoma and infiltration, with delayed external secondary hemorrhage, and (2) those associated with a pleural laceration and continued *intrapleural* hemorrhage. This latter injury produces symptoms and signs of an increasing intrapleural pressure and mediastinal shift which *progresses until death ensues in spite of oxygen and thoracentesis* unless the chest wall artery is ligated. This is in direct contrast to hemothorax resulting from lung injury which is usually controlled by the pulmonary tamponade from the associated hemothorax. Massive external secondary hemorrhage and signs of uncontrollable, progressive, intrapleural hemothorax demand immediate exploration of the wound and careful ligation of the mammary and intercostal arteries involved. This cannot be done satisfactorily or effectively except by partial removal of the costal cartilages or ribs in this region. The operation is relatively simple and no patient should be allowed to die from this type of injury.

The Axillary Artery

Since the axillary artery is superficial, there is usually a pulsating mass and the bruit is quite obvious both by palpation and auscultation. These wounds are usually associated with signs of nerve injury due either to direct injury of the axillary cords by the same missile as that which produces the arterial injury or to the associated infiltration and pressure of the hematoma. Even though the external wound is frequently very small, the danger of secondary hemorrhage is great in this type of wound and these patients should be operated on at once. In order to do this type of operation safely, it is essential to have a fully equipped *operating room, a trained anesthetist, adequate assistants, and continuous transfusions* throughout the procedure. It is best to start the operation by tying cannulas in the ankle veins of both legs so that if one transfusion should plug up at a crucial time during the operation, the other would carry on satisfactorily, or if a severe hemorrhage is encountered, both can be run in as rapidly as possible.

The general principle of approach to this type of injury is to avoid entering the false aneurysm at any point before the major artery and vein, both proximal and distal to the injury, and all significant branches entering into this section of the injured vessel are fully controlled. This is accomplished by a complete and accurate exposure of these vessels proximal and distal to the infiltrated area of the false aneurysm and control of the flow through these vessels by tension on small soft catheters placed around these vessels. The vessels are then further exposed until finally the false aneurysmal sac is entered and the actual injury to *the artery visualized. Even with full control* of the injured major artery and vein both proximal and distal to this region and all major entering branches to this area, there is still a rapid flow of blood from the injured area into the sac. The artery and vein are then ligated carefully, both distal and proximal to the injury, and the injured area is excised, carefully preserving for collateral circulation all branches which do not immediately enter into the area to be excised.

For the axillary injuries, the approach is through an incision from the middle

third of the clavicle across the pectoral region to the axilla (Fig. 489). Usually the pectoral muscle is so infiltrated with hematoma and so indurated that simply splitting the fibers would not give adequate exposure of the vessels proximal to the injury without inadvertently opening the false aneurysm, which would immediately prove fatal. Adequate exposure can be obtained only by sectioning the pectoralis major in its tendinous insertion on the humerus, and turning it back, fully exposing the axillary contents. The artery and vein are then isolated care-

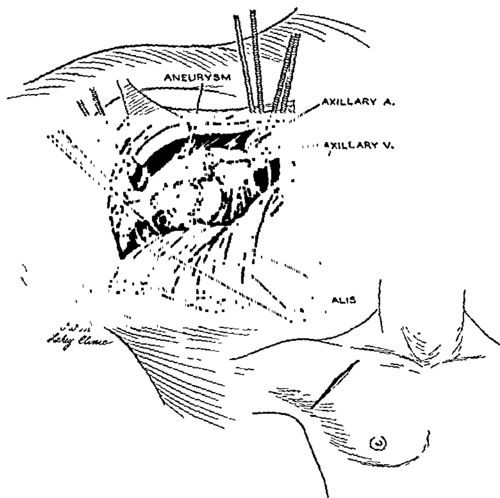


Fig. 489. Exposure of the axillary aneurysm, and approach and control of the axillary vessels; inserts shows line of incision.

fully just below the clavicle and catheters passed around these structures for tourniquet action. These vessels are then likewise isolated distal to the false aneurysm, usually at the margin of the axilla, and catheters passed around the vessels at this point. The pectoralis minor is then sectioned and turned downward, completely exposing the axillary vessels. Gradual dissection and development of the vessels are then carried out both from above and below, carefully isolating and preserving the axillary cords which are in close contact with the vessels. Finally, the neck of the false aneurysmal sac is encountered and it is then necessary to open the sac and accept a certain amount of rather brisk hemorrhage while the remainder of the artery is isolated and the ligation carried out both distal and proximal to the laceration, and the injured area excised.

In many instances the vein is involved and there is an arteriovenous aneurysm in addition to the false arterial aneurysm. In such cases it is absolutely essential *that the vein be excised as well, but this is equally important in those cases in* which the vein is not involved, since this procedure facilitates the circulatory adjustment following the ligation of the artery. No attempt is made at this operation to suture lacerated or injured axillary nerve cords. The pectoralis major muscle tendon is then reunited with silk sutures and the wound closed, draining the wound with a small Penrose drain.

The Subclavian Artery

Injury to the subclavian artery is quite similar in many ways and in diagnostic findings to the injuries of the axillary artery. Being more deeply seated, the ex-



Fig. 490. False aneurysm in conjunction with arteriovenous aneurysm of the subclavian vessels, venogram showing block of the vein at the site of injury.

ternal infiltration and hematoma are much less obvious and the diagnosis is made chiefly by the presence of a bruit. This is a rough bruit throughout systole or during the entire cardiac cycle if combined with an arteriovenous aneurysm. It is a common finding in both the axillary and subclavian arteries to have not only a false aneurysm but an arteriovenous aneurysm as well. This added complication of the arterial injury can often be diagnosed by an increase in the venous pressure in the arm involved, and the venograms are most characteristic (Fig. 490).

Functional bruits are fairly common in this region and must be distinguished carefully. This can be done by examining the patient frequently over a period of time. A functional bruit will vary considerably from examination to examination

and also in relation to the position of the patient and the position of the extremity. Likewise, simple compression from external pressure and infiltration about the artery may produce a bruit. It is, again, essential to distinguish, if possible, between that and the true lacerated vessel with a false sac, in which surgery is essential to effect a cure. If there is any question regarding the diagnosis of the type of bruit heard, that is, whether it is due to a false aneurysm or to a combination with an arteriovenous aneurysm, or whether it is due to external

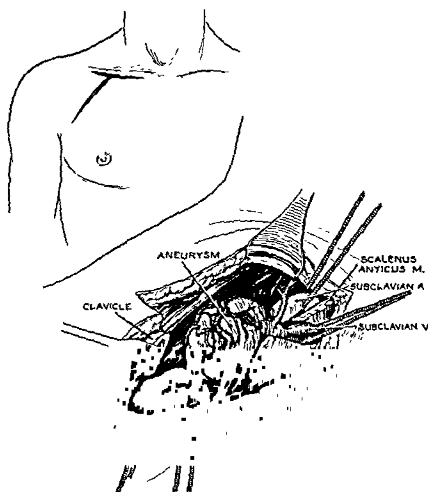


Fig. 491. Exposure of subclavian aneurysm, and approach and control of the subclavian vessels, insert shows line of incision.

pressure or a functional bruit, it is usually safe to keep these patients in bed under observation, and as long as there are no signs or symptoms of further infiltration or cardiac damage, a careful period of observation can be carried out. The functional bruits can be ruled out by their inconstant nature; the bruits caused by pressure gradually decrease in intensity as the external signs of infiltration diminish and the patient's condition improves.

Although the false aneurysms and arteriovenous aneurysms of the subclavian artery are most hazardous surgical problems, the same general principles of approach apply as described under the procedure for axillary arterial injuries. It is essential first to make a low cervical incision above the medial end of the clavicle (Fig. 491). The lateral clavicular insertions of the sternomastoid muscle are cut,

the carotid sheath and its contents retracted medially, the scalenus anticus muscle is exposed, and the phrenic nerve freed and retracted medially. The scalenus muscle is then cut, the subclavian artery exposed, and a catheter passed around it for tourniquet action. Connecting this incision, a diagonal incision is then made across the pectoral region similar to that for an axillary exposure except that the pectoral muscles are split for exposure of the axillary vessels immediately below the clavicle and catheters passed around them for control. The clavicle is then cut across and the ends retracted, or better, the mid section is resected, giving a wide exposure of the injured area. Dissection of the subclavian vessels is then carefully carried out in both directions until the neck of the sac of the false aneurysm is isolated and entered, here again accepting considerable bleeding in the final identification of the actual opening in the artery. The artery and vein are then ligated proximal and distal to this laceration and the injured area excised

The brachial cords are, of course, closely associated with the aneurysmal sac and often direct damage has been done to these nerves and further damage can be demonstrated from direct pressure and the infiltration of these trunks. It is necessary to isolate them carefully and produce no operative trauma to these cords, but no attempt is made to suture any of the cords that are found injured. The clavicle is then wired together and the wound closed, draining the wound with a simple Penrose drain.

The Innominate Artery

The diagnosis is made primarily on the basis of a bruit and roentgenologic findings of infiltration of the superior mediastinum, as well as induration extending up into the suprasternal notch and the base of the neck. Submanubrial and cervical pain are the outstanding symptoms. Again, because of the very grave nature of the operation, it is absolutely necessary to be certain that this bruit is not due to some external infiltration and pressure on the artery. As long as the patient is kept in bed under close observation and there are no signs of cardiac hypertrophy or change, the surgical procedure can be delayed to establish beyond question of doubt the presence of a false aneurysm. Several cases were observed in which the roentgenologic signs of mediastinal infiltration and the bruit disappeared after weeks of observation. Continued pain, however, especially with exacerbations of pain, and increasing or undiminished bruit or any signs of cardiac effects demand surgery.

The same general approach is essential in this type of operation. Because of the extremely close relationship of the vessels in the superior mediastinum and the base of the neck, it becomes much more difficult to avoid entering the false aneurysmal sac before adequate exposure and complete control of the injured vessel, *both proximally and distally, is obtained A transverse incision is made* across the midneck above the clavicles and the suprasternal notch, which is connected with a vertical incision over the mid-manubrium (Fig. 492). The suprasternal notch is exposed and the soft tissues are retracted to expose the entire manubrium and the peristernal second and third interspaces. The mediastinal tissues are then very carefully freed from the undersurface of the manubrium and a short section of the sternum down to the third interspace. The mediastinal structures are protected with a thin spatula, and the manubrium is then split in

the midline with an electric saw, carrying the division downward into the sternum to the level of the third interspace and, laterally, connecting the interspaces on either side. The manubrium and sternum are then retracted widely with a rib-spreading retractor. This gives a good exposure of the entire superior mediastinum and the arch of the aorta. The innominate artery is isolated at its origin from the arch of the aorta and a catheter passed around it for tourniquet action. The innominate vein also is isolated and controlled in a similar way. Just beyond

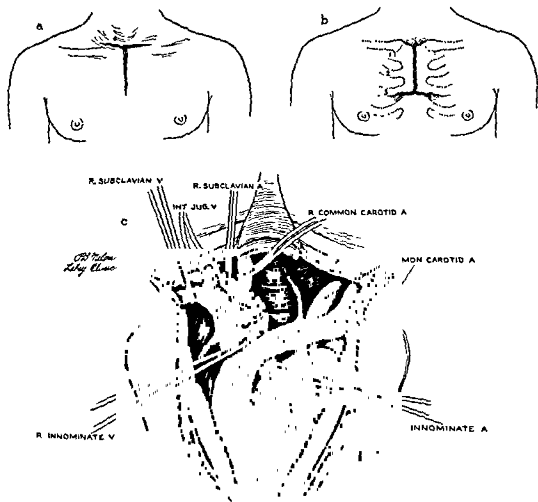


Fig. 492. Exposure of innominate aneurysm. *a*, Line of skin incision, *b*, line of section of the manubrium and upper sternum, c, approach and control of the innominate vessels and their major branches distal to the aneurysm.

the bifurcation of the innominate vessels, the subclavian and the common carotid arteries and their associated veins are isolated and likewise controlled with catheters. Finally, with full control both proximally and distally by means of traction on the catheters, the aneurysmal sac is isolated and the injured section of the artery excised after careful ligation both proximal and distal to the laceration. The manubrium is then wired together and the *superior mediastinum* drained with a simple Penrose drain.

SUMMARY

In traumatic arteriovenous aneurysms, associated with or without false arterial aneurysms, the treatment of choice is quadruple ligation and excision. In those

lesions located distal enough in the extremities so that a tourniquet can be used, a direct and relatively simple resection can be done in a bloodless field. In the more proximally located lesions—in the upper thigh, groin, abdomen, neck, shoulder and chest—a most exacting surgical management is essential if these patients are to survive their operations. The basic principles of the surgical approach and the technical aspects are presented in detail in some of these proximal lesions.

II. CONGENITAL ARTERIOVENOUS AND CIRSOID ANEURYSMS

Abnormal arteriovenous communications are serious vascular lesions producing profound local and general physiologic circulatory effects. In addition to their

Table 1. Congenital Arteriovenous and Cirsoid Aneurysms (22 Cases)

CASE	ANATOMICAL LOCATION	TYPE OF OPERATION
		Head and Neck
1	Scalp, forehead, eye	Multiple staged excision
2	Forehead, nose	Ligation of right common carotid artery
3	Neck	[illegible]
4	Neck	
5	Neck	
6	Neck	Excision, superior thyroid arteriovenous aneurysm
7	Scalp	Excision, one stage
		Upper Extremity
8	Right hand	Excision, one stage
9	Left palm	Excision, one stage
10	Right forearm	Excision, one stage
11	Right hand	Excision, one stage
12	Right upper arm	Excision, one stage
		Lower Extremity
13	Left upper thigh and buttock	Ligation of femoral profunda artery and internal iliac artery
14	Left buttock	Ligation of internal iliac artery Excision as second stage
15	Left upper thigh	Excision, one stage
16	Right buttock	Ligation of internal iliac artery and profunda of femoral artery
17	Right foot	Excision, one stage
18	Right lower leg	Excision, one stage
19	Popliteal	Excision, one stage
		Visceral
20	Pancreas, duodenum, stomach	Resection, two stages
21	Spleen	Splenectomy
22	Right kidney	Nephrectomy

clinical significance, these vascular lesions are equally important surgically since there is no other effective form of treatment and the surgical management of many of these lesions is often difficult and extremely hazardous. William Hunter, in 1757, was the first to recognize an arteriovenous aneurysm as a direct com-

munication between artery and vein, and Dupuytren, Bramann, Matas, Halsted, Reid, Pemberton, Holman and others have made valuable contributions relative to the nature and surgical management of these interesting vascular lesions.

There are two distinct types of arteriovenous aneurysms, the acquired or traumatic, and the congenital. The significant difference between these two types lies in the fact that in the acquired type there is usually a distinct history of a penetrating wound and the resulting communication between the artery and vein involved is usually single and relatively large. In the congenital lesions, on the other hand, there is no history of antecedent trauma and the arteriovenous communications are most often multiple and of small caliber. In addition, the congenital lesions may be present for many years before symptoms develop, which probably represent a certain stage in the progressive enlargement of the original, extremely small communications. The more localized congenital lesions have been classified in this study as congenital arteriovenous aneurysms and the more diffuse hemangioma-like lesions are classified as cirsoid aneurysms. There is, however, no known significant pathologic difference between these two types of congenital lesions and this is, therefore, a purely descriptive classification.

I have previously published[1] some of my experiences with arteriovenous aneurysms of traumatic origin and I will not discuss this type further other than to say, in passing, that the technical management of some of the more proximally located traumatic arteriovenous aneurysms may be one of the most hazardous surgical procedures that we undertake today. Certainly, surgical experience gained with either type will be helpful in the management of the other type.

I wish to present a group of 22 cases of congenital arteriovenous and cirsoid aneurysms in widely diversified areas of the body and give our surgical experiences with them (Table 1).

GENERAL CLINICAL FEATURES

The general clinical features of these congenital lesions are most interesting. In the majority of cases the development and the progression of the lesion are extremely slow, usually years. Eventually, however, they show all of the classical findings, both local and general, that are common with these lesions. Locally, they exhibit palpable and often visible venous pulsation, either visible superficially or when exposed surgically; a palpable thrill and an audible bruit continuous throughout the cardiac cycle, and finally, the more distant circulatory effects of cardiac hypertrophy and eventually cardiac decompensation.

Some of these lesions have been so localized and small that none of these general circulatory effects have been present, and the diagnosis has been made purely on the presence of the characteristic bruit. This characteristic bruit is the one constant diagnostic finding in these cases and it is, therefore, important to listen with a stethoscope routinely over all vascular lesions of this sort. Other diagnostic aids that are often possible are the demonstration of an elevation of venous pressure, an elevation of oxygen content of the venous blood and, thirdly, angiography with roentgenologic evidence of an arteriovenous shunt (Fig. 493). This latter roentgenologic study, however, is rarely absolutely necessary for diagnosis and is, therefore, done infrequently.

MANAGEMENT

The treatment of these vascular lesions has varied considerably with the extent and location of the lesion. We have seen several children who have cirsoid aneurysms of the lower extremities with extensive involvement of the entire leg and with obviously multiple, very small arteriovenous communications, with increased venous pressure and oxygen content of the venous blood,



Fig 493. Arteriogram showing arteriovenous aneurysm and communications between brachial artery and vein.

and associated hypertrophy and greater length of the leg, but without any distant cardiac effects. An amputation at the level of the groin would be the only possible way of eliminating such a lesion. We have elected to do nothing surgically in these cases and to keep the patients under observation for the development of any general circulatory effects before recommending such radical surgery.

Some cases of cirsoid aneurysms have been handled by single or multiple stage local excisions. We have had one case of cirsoid aneurysm of the scalp and forehead, with deeper involvement as well, in which the aneurysm has been partially removed on three different occasions, some years apart, when-

ever the recurrent lesion has become very large, unsightly and distressing to the patient. This has been a hazardous procedure because of blood loss, since clamping, tying, or electrocoagulation did not control the bleeding in this type of friable tissue, and excision could be accomplished only by excising a few centimeters at a time and closing the soft tissues at the same time with through and through mattress sutures.

A third group has been managed by simple ligation of the arterial trunk associated with the lesion, such as the internal iliac artery for a gluteal lesion and

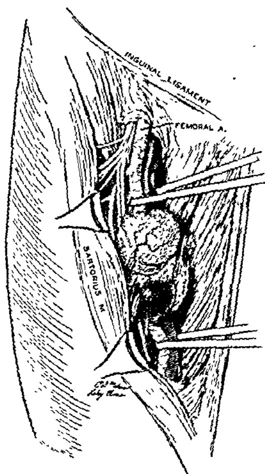


Fig 494. Femoral arteriovenous aneurysm showing required wide exposure and control of femoral vessels both proximal and distal to the lesion.

a femoral profunda artery for a posterior, upper thigh lesion. Simple, proximal arterial ligation of this type will cause a temporary regression and control the lesion, but it will recur in a matter of a few months In one of the gluteal lesions in which a simple arterial ligation was done, at the first signs of recurrence, sclerosing injections were tried, again with only the most transitory beneficial effect.

The treatment of choice is surgical extirpation of the lesion. As already stated, this is not always safe or possible, or may necessitate a staged procedure. In the lesions that are located peripherally in the extremities and permit the use of a tourniquet, a precise excision can be done with relative ease and complete safety. In the more proximally located lesions, such as the neck, thigh and but-

tock, it is absolutely essential that the major artery and vein involved be isolated and controlled at a safe distance, both proximal and distal to the lesion,

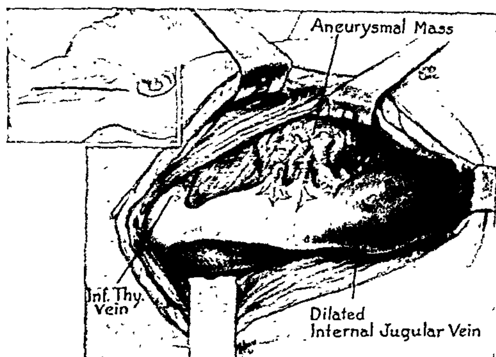


Fig. 495. Carotid-jugular arteriovenous aneurysm, showing surgical approach and exposure.

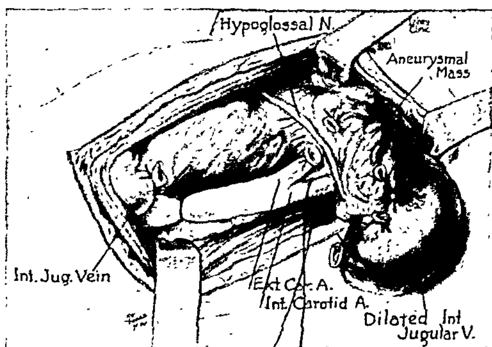


Fig. 496 Carotid-jugular arteriovenous aneurysm (see Fig. 495), showing resection.

before making any effort to remove the lesion itself (Figs. 494, 495 and 496). In the gluteal lesions we have preferred to ligate the internal iliac artery transperitoneally as a preliminary and separate stage, several days before resecting

the gluteal lesion. The second stage of excision is a long, difficult procedure requiring many hundreds of ligatures.

Congenital arteriovenous aneurysms may also occur in the viscera. We have seen these lesions in the stomach, duodenum, pancreas, spleen, lung and kid-



Fig. 497. Renal arteriovenous aneurysm, showing exposure at operation.



Fig. 498. Renal arteriovenous aneurysm, pathologic specimen removed at operation.

ney. In these cases an associated hemorrhage has been a common presenting symptom. In addition, the cardiac effects have also been prominent. Exsanguinating hemorrhages and a damaged heart have made these cases serious

surgical risks. Resection of the organ involved is mandatory to save these patients and unusual care must be taken in the surgical approach and the control of the blood supply to the organ at a safe distance before making any attempt to mobilize either the lesion or the organ in question (Figs. 497 and 498).

Congenital arteriovenous aneurysms and cirsoid aneurysms should be resected whenever technically possible in order to obtain the highest percentage of permanent cures. Safety factors, such as staging, complete control of the major blood supply at all times, as well as the most painstaking hemostasis during the protracted actual excision of the larger lesions, will make it possible to cure these patients of their serious vascular lesions without prohibitive risk and mortality.

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REPAIR OF INCISIONAL HERNIA

RICHARD B. CATTELL

Incisional or ventral hernia is a frequent late complication of abdominal surgery. It is usually the result of partial disruption of the fascial layer followed by an opening in the peritoneal layer. Unless actual eventration occurs it may not be recognized during the immediate postoperative period. It is usually the result of a wound complication such as bleeding or infection in the abdominal wall. If partial disruption can be recognized during the postoperative period by discharge of blood or serosanguineous fluid from the wound later hernia can usually be avoided if immediate secondary closure of the wound is accomplished. Incisional hernia most often occurs in obese individuals and is particularly prevalent when there has been a postoperative pulmonary complication. It is also common when abdominal surgery has been undertaken for malignant disease in debilitated and poorly nourished patients.

With better selection of the abdominal incision, the incidence can be decreased. The employment of transverse incisions and those which avoid cutting more than one or two nerves likewise will result in a stronger abdominal incisional scar.

The repair of large incisional hernias may be quite difficult by any type of procedure, particularly those with large defects of the abdominal wall. The use of nonabsorbable sutures in effecting the repair, and the use of fresh fascia as described by Gallie have given improved results. Alloy steel wire has been effectively utilized by Babcock and others to effect the repair. In large defects Koontz has described the use of large squares of tantalum mesh.

In 1942, I described a simplified technic for repair of large incisional hernias which was found quite practical. It has now been employed over a period of ten years with good results.

Patients who have large incisional hernias are frequently poor risks either because of obesity or because of cardiovascular or renal conditions. Because of the frequency of postoperative complications in this group of patients they should be very carefully studied previous to advising operation. Pulmonary complications and thrombophlebitis may follow repair but can usually be avoided. Obese patients should be put on a strict reduction diet and repair should be delayed whenever possible until their weight falls within a normal range. Because of the marked changes in intra-abdominal pressure produced by the repair, it is well during the period of preparation to have them fitted with an abdominal belt to reduce the contents of the hernia as far as possible within the abdominal cavity.

In some patients, because of marked disability or abdominal pain, operation must be advised before weight reduction. Likewise, when incarceration is present

Originally published in Surgical Clinics of North America, 29:787–793 (June) 1949.

with threatened or impending strangulation of the contents of the sac, operation must be carried out at a less advantageous time. With large hernias, at times the skin becomes ulcerated because of excessive pressure, and immediate operation should then be advised. Under these circumstances the technic which will be described is particularly applicable since it can be carried out with a minimum of technical difficulties even in very obese patients.

The usual technic employed for the repair of incisional hernia includes isolation of the sac and its contents, following which the layers of the abdominal wall are dissected out separately. This is frequently a long and tedious dissection and even when carried out in the best manner possible it may result in obtaining quite weak layers that are not easily sutured owing to their irregularity and weakness.

The chief difference in the conventional method of hernia repair and the plan which will be described is that the strong layer of the ring is not disturbed. This ring consists of fragments of the peritoneum, muscle and fascia and, in the upper abdomen, portions of the posterior rectus sheath and transversalis muscle. The layers of the abdominal wall are identified subsequently during the repair at some distance from the ring.

TECHNIC

After applying traction to the previous incisional scar, an elliptical incision is made around the scar incorporating the excess skin of the abdominal wall (Fig. 499, *a*). By firm traction, the contents of the sac will usually fall away. The incision is then continued outward through the layer of fat until the fascia is encountered (Fig. 499, *b*). These lateral flaps are freed up for a considerable distance laterally beyond the ring of defect, leaving a broad surface of fascia exposed. It is a relatively bloodless procedure. Traction is maintained on the sac and sharp dissection is carried out medially around the entire neck of the sac at its junction with the fascia (Fig. 499, *b*).

When a wide dissection of the flap has been carried out, the skin is incised over the sac, which is entered. The abdominal contents are completely freed from the sac and the dissection carried out well beneath the abdominal wall for the full circumference of the defect. It is frequently advisable to excise large portions of omentum. The skin is excised from the sac, and the fat cut away from its entire surface (Fig. 500, *a*). With the defect of the abdominal wall outlined, the peritoneum is approximated in a longitudinal direction with a continuous heavy chromic interlocking suture, including all layers of the abdominal wall that are attached to the hernial ring (Fig. 500, *b*). This can be accomplished even when large defects are present.

The large redundancy of sac is cut away at a distance of 2 cm. from the previous suture line This redundant portion of the sac, again containing portions of peritoneum, muscle and fascia, is approximated with interrupted or continuous chromic sutures immediately overlying the first suture line (Fig 501, *a*). In some patients with large defects these two layers are closed by means of alloy steel wire and the operation is concluded with this simple repair. This is effective in the upper part of the abdomen if the previous incision has been made in the linea alba or midline. At times it is sufficient in lower midline

incisions as well. It is recommended, however, that a further layer closure be effected, as will be described.

An elliptical incision is made at a distance of 2 cm. on each side lateral to the previous suture line in a position as indicated by the dotted line in Figure 501, *a*. This exposes the muscle on either side, which may be freed up to any

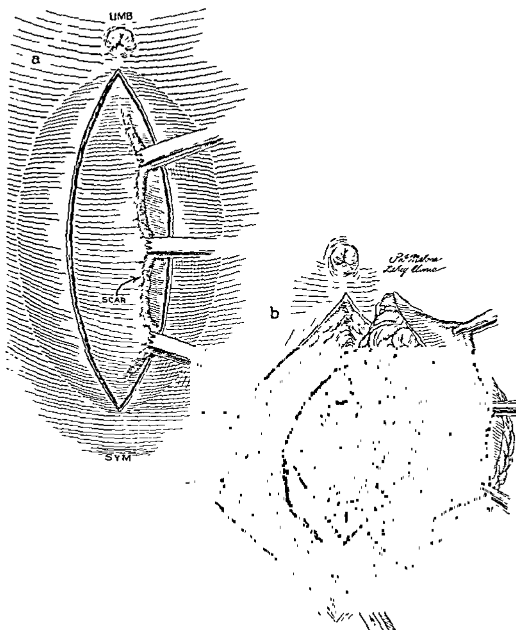


Fig. 499. *a*, The outline of the hernia is shown. An elliptical incision has been made enclosing the scar and excess skin. *b*, Lateral flaps have been freed, exposing the fascia. The dissection is then carried medially to expose the edge of the defect in the abdominal wall.

extent desired. The medial borders of the elliptical incision are approximated as the third layer, as indicated in Figure 501, *b*.

The fascial layers are freed up for a considerable distance from the muscle and interrupted sutures are used to approximate the fascia at the upper and lower angles of the incision. This is done to take the tension off the muscle. Muscle sutures are then alternated with fascial sutures until the fourth and

through the rectus muscle. It has been used more often in lower midline sions and for low right rectus incisional hernias. The same principle has employed in hernias of all sizes in all quadrants of the abdomen. In our ex ence, repair effected by this method is followed by a very low incidenc complications and recurrences.

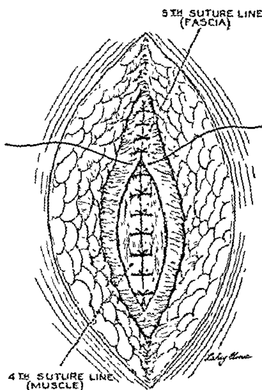


Fig. 502. Alternating sutures are taken to approximate muscle and fascia.

SUMMARY

A technic for the repair of incisional hernia has been presented whic applicable to most incisional hernias irrespective of size. It has been car out frequently in very obese patients when, because of complications, reduc of weight has been inadvisable.

The chief difference between this method of repair and the one gener employed is that the repair is carried out after dealing with the sac and contents without separate dissection of the layers of the abdominal wall. ' hernial ring is approximated, following which the layers are identified approximated over this preliminary closure.

REFERENCE

1 Cattell, R. B · An unusual technic for the repair of incisional hernia. S. Clin. N America 22 795–799 (June) 1942.

THE REPAIR OF INGUINAL HERNIAS

KENNETH W. WARREN

The endless stream of medical literature describing methods of surgical repair of inguinal hernias reflects a disturbing lack of agreement regarding the fundamental anatomical and technical requirements for success in this field. Differences of opinion in assessing the relative importance of the various anatomical structures which constitute the abdominal wall in the inguinal region are central to this state of confusion. Ancillary sources of disagreement revolve around the choice of suture material, the utilization of continuous or interrupted sutures, the period of postoperative recumbency and the time of resumption of full physical activity.

INDIRECT VERSUS DIRECT INGUINAL HERNIA

In the literature of the past much attention was directed toward the differentiation of these separate types of hernias, from the standpoint of both clinical recognition and surgical repair. That the two types are dissimilar in location and origin cannot be seriously questioned. Nor can one substantiate the thesis that the anatomical requirements for adequate repair of these types of hernias are always the same, and yet one of the common errors in arriving at a reasonable concept of inguinal hernia repair is failure to recognize that an indirect hernia with a greatly widened internal ring (which widening always occurs at the expense of the transversalis fascia) is similar in its fundamental defect to a direct hernia.

It would be better, perhaps, for surgical considerations alone, to regard the small, indirect inguinal hernia in children and young adults in a separate class, for all that is required for their surgical elimination when the internal ring is not dilated is the complete excision of the sac with high ligation at its neck.

In large indirect hernias in which the transversalis fascia constituting the internal ring has been disrupted (and it may be disrupted all the way to the pubic spine by a progressively expanding indirect hernia) and in direct hernias, the primary concern in repair is the restoration of the integrity of the transversalis fascia. To the extent that the essential anatomical defects in indirect hernias with markedly enlarged internal rings and in direct hernias, with disruption of the transversalis fascia in Hesselbach's triangle are the same, the surgical repair of each variety should be similar.

Many authors in recent years, particularly Bartlett, Zimmerman, Fallis, Anson and McVay, and Harkins, have stressed the significance of the transversalis fascia. Fallis has pointed out that in direct inguinal hernia the rectus muscles tend to be narrow in their inferior extent, that the external inguinal ring is congenitally enlarged and the the internal oblique and transversus abdominis muscles fail

Originally published in Surgical Clinics of North America, 29.795–804 (June) 1949.

to become fibrous until they reach the lateral edge of the rectus sheath, thereby precluding the formation of any significant conjoined tendon.

Anson and McVay have been impressed during their anatomical and surgical dissections with the relationship of the transversalis fascia to the inguinal and to Cooper's ligament. They contend that *the transversus aponeurosis does not* attach itself to the inguinal ligament, but inserts into Cooper's ligament, and they have described a type of repair which approximates the medial aspect of the transversalis fascia to Cooper's ligament. Harkins has utilized this maneuver and attempts to justify its uniform application to all types of inguinal and femoral hernias.

THE REQUIREMENTS FOR INGUINAL HERNIA REPAIR

There are certain technical aspects of the surgical treatment of hernia, unrelated to controversial anatomical considerations, which may appear inconsequential, but which may prove decisive in the ultimate success or failure of any method of repair.

Anesthesia. The muscular relaxation, the placid movements of the abdominal wall and the absence of intra-abdominal tension resulting from spinal anesthesia combine to make this the anesthetic method of choice in the repair of hernia.

Silk or similar nonabsorbable suture material is preferable to catgut. The employment of buried silk sutures presumes a high regard on the part of the surgeon for sharp dissection, careful hemostasis and the absence of undue tissue tension.

Early ambulation is safe and proper in most instances, but reducing the hospital stay materially below two weeks is a questionable practice.

Routine opening of the peritoneum at the internal ring in both direct and indirect inguinal hernia should be observed. This maneuver will accomplish several things. It will insure that an indirect sac will not be overlooked. It will permit an assessment from within the abdominal cavity of the status of Hesselbach's triangle and the femoral canal. It will obviate the greatest risk of injury to the bladder and it will permit the conversion of the direct sac, when present, to an indirect sac, after the manner of Hoguet. The opening of the peritoneum, preferably at the internal abdominal ring, should be practiced in every repair of inguinal hernia.

Anatomical requirements for repair. If one accepts the thesis that the transversalis fascia constitutes the first restraining force the anterior abdominal wall offers to increased intra-abdominal tension, one must conclude that the restoration of the integrity of the transversalis fascia, in either direct or indirect hernias, is the *sine qua non* of an adequate repair. If this important structure is to be restored to its normal functional integrity it must be thoroughly exposed from the anterior pubic spine to the superior margin of the internal abdominal ring. This exposure is facilitated by the excision of the cremasteric muscles. It is important in indirect inguinal hernias with widening of the internal abdominal ring to detach the cremasteric muscle from the margins of the transversalis fascia at the internal ring in order that these margins may be approximated about the spermatic cord after the hernial sac has been eliminated. It is even more advantageous to remove the lower fibers of the cremasteric muscle when a direct defect

is present so that the medial and lateral margins of the transversalis fascia in Hesselbach's triangle can be recognized and approximated without intervening cremasteric fibers. Bartlett has emphasized repeatedly the validity of this procedure in his writings on his concept of repair of inguinal hernia.

Reinforcing the transversalis fascia. In indirect hernia with minor degrees of disruption of the transversalis fascia at the internal ring, no elaborate means of reinforcement are required. Simple approximation of the freed margins of the transversalis fascia constituting the internal ring will suffice. The vulnerability of Hesselbach's triangle, on the other hand, is serious in direct inguinal hernias, and adequate surgical repair necessitates further reinforcement.

Innumerable approaches to this problem have been pursued, ranging from Bassini's approximation of the conjoined tendon to the shelving edge of the inguinal ligament, to recent attempts to utilize Cooper's ligament instead. The inadequacy of the former maneuver, in many instances, is related to the very limited extent or utter absence of a conjoined tendon and particularly to its unavailability except in the lowermost part of Hesselbach's triangle. More recently, Anson and McVay have questioned the reasonableness of utilizing the inguinal ligament for any part of the repair of inguinal hernias. They contend that the transversalis fascia does not insert into the inguinal ligament and they decry further the use of a mobile bastion, such as the inguinal ligament, on structural grounds.

Zimmerman, in a brief critique on the McVay concept, has pointed out (1) that the mobility of the inguinal ligament is not a serious objection to its utilization in inguinal hernia repair, since failures related to the mobilization of the inguinal ligament would appear as femoral recurrences, a type of recurrence rarely seen; (2) that the insertion of sutures into the anterior pubic ligament (Cooper) is difficult and hazardous in terms of possible injury to the femoral vein, and (3) that these sutures into Cooper's ligament cannot be carried far enough lateralward to protect the entire area of Hesselbach's triangle. Despite these objections, with which the present author agrees, excellent results have been reported with the utilization of this method of repair, and this means of reinforcing the transversalis fascia at the lower level of the inguinal canal is occasionally employed.

The method of adding suport to the floor of the inguinal canal upon which we generally depend comprehends the utilization of a relaxing incision in the internal oblique fascia near the midline where it constitutes part of the anterior rectus sheath, and approximation of the dense aponeurotic structure at the lateral margin of the rectus sheath to the shelving edge of the inguinal ligament.

In direct hernias and in indirect ruptures with disruption of the transversalis fascia, the floor of the inguinal canal is further reinforced by imbricating the aponeurosis of the external oblique beneath the mobilized cord structures after the manner of Halsted.

TECHNIC

An incision is made in the skin and subcutaneous tissue about 2 cm. above and parallel to the inguinal ligament, extending from the level of the internal abdominal ring to or slightly beyond the spine of the pubis (Fig. 503). The

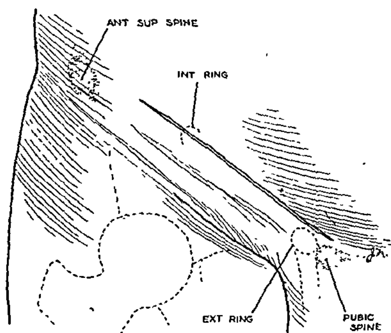


Fig. 503. Topography of right inguinal region showing skin incision approximately 2 cm. above and parallel to the inguinal ligament, extending from the spine of the pubis to a point slightly below the anterior superior spine of the ilium.

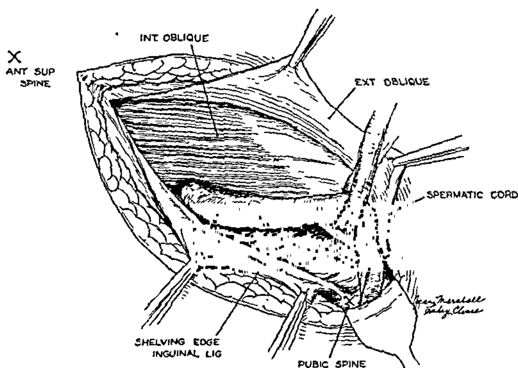


Fig. 504. The aponeurosis of the external oblique has been divided in the direction of its fibers The lateral flap is reflected outward, revealing the shelving edge of the inguinal ligament. The spermatic cord is retracted medially, exposing the pubic spine.

segment of the spermatic cord between the external abdominal ring and the scrotal entrance is retracted medially, exposing the spine of the pubis. The aponeurosis of the external oblique muscle is incised and the lateral leaflet is mobilized to the depth of the shelving edge of the inguinal ligament (Fig. 504). The medial flap is mobilized to the point of its insertion into the anterior rectus sheath near the midline. The relaxing incision in the anterior rectus sheath is made at this time (Fig. 505). The cord is mobilized from the inferior aspect of the inguinal canal, thus exposing the spine of the pubis at the transversalis level.

The cremasteric muscle and fascia are incised and the cord structures are delivered from these investing membranes. The attachments of the cremaster

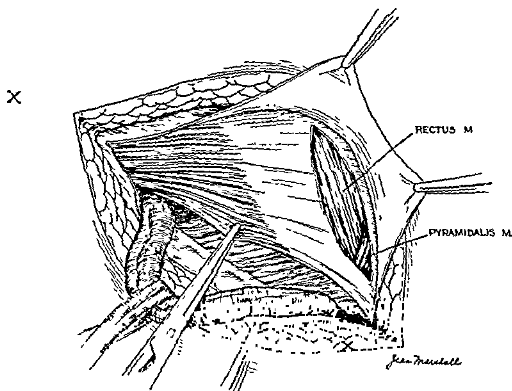


Fig. 505. The medial flap of the aponeurosis of the external oblique has been reflected medially, and the anterior rectus sheath has been incised vertically, near the midline, thereby relaxing the lateral margin of the rectus sheath.

are severed from the lateral and medial margins of the transversalis fascia constituting the internal abdominal ring. The cremaster fibers are dissected from the floor of the inguinal canal and are clamped and divided below the level of the pubic spine (Fig. 506). The direct defect in Hesselbach's triangle is thoroughly exposed.

The cord is placed on slight tension at the internal ring and the indirect sac is identified and opened. If no indirect sac is present, the normal reflection of peritoneum at the internal abdominal ring is grasped and opened. With an examining finger inserted into the peritoneal cavity an appraisal is made of (1) the size of the internal ring; (2) the status of the transversalis fascia in Hesselbach's triangle, and (3) the integrity of the femoral canal.

In indirect hernias, the sac is separated from the cord and the neck is closed

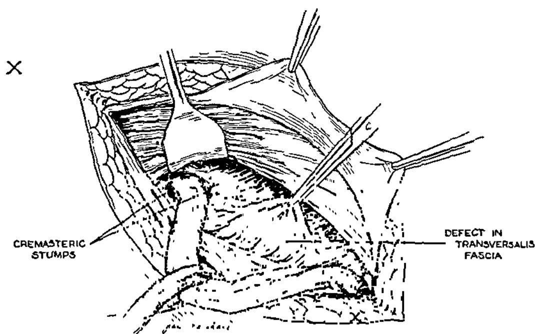


Fig. 506. The cremaster muscle has been removed, exposing thoroughly the direct defect in the transversalis fascia. The ligated stumps of the cremaster muscle are visible on the lateral and medial aspects of the internal abdominal ring.

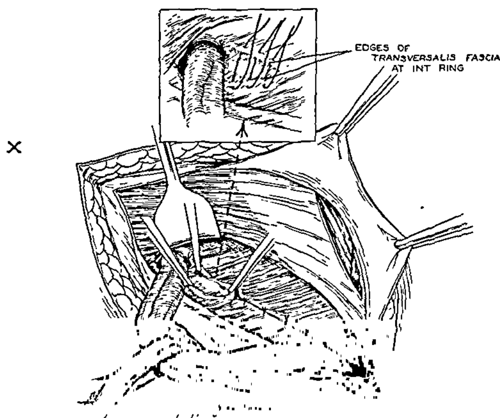


Fig. 507 The integrity of the transversalis fascia in Hesselbach's triangle has been restored by a series of interrupted silk sutures, invaginating the defective area shown in Figure 506. The conversion of the direct hernial sac into an indirect one is not shown in the illustration.

The inset shows the reconstruction of the internal abdominal ring by approximating the margins of the transversalis fascia snugly about the cord.

with a purse-string suture. If the indirect sac is large, it is incised circumferentially at its neck and the distal portion is not removed. Direct sacs are converted into indirect ones, as advocated by Hoguet.

The plastic reconstruction of the internal ring is accomplished by approximating the lateral and medial margins of the transversalis fascia with interrupted sutures of medium silk (Fig. 507, *inset*). Defects in the transversalis fascia overlying Hesselbach's triangle are closed by imbricating the structure with a row of similar sutures (Fig. 507). The floor of the inguinal canal is reinforced by approximating the dense aponeurotic structure which constitutes the lateral margin of the rectus sheath to the shelving edge of the inguinal ligament (Fig. 508). This maneuver is facilitated by the relaxing incision pre-

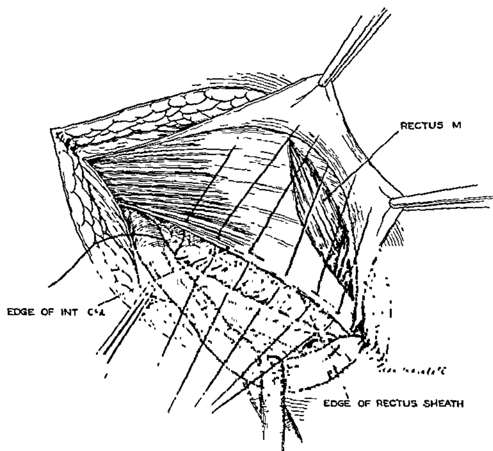


Fig 508. The lower edge of the rectus sheath is being approximated to the shelving edge of the medial third of the inguinal ligament in order to reinforce the reconstructed transversalis fascia. Above this level the internal oblique muscle is sutured to the inguinal ligament. The advantage of the relaxing incision in the anterior rectus sheath will become evident as these sutures are tied.

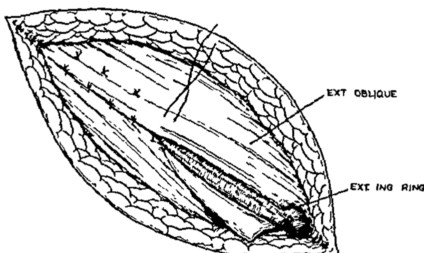
viously made in the rectus sheath. In indirect hernia with minor degrees of disruption of the transversalis fascia the external oblique aponeurosis is imbricated above the cord (Fig. 509, *a*). In direct hernia and in indirect hernia associated with loss of integrity of the transversalis fascia, the external oblique is sutured beneath the cord as described in Halsted's original operation (Fig. 509, *b*). Approximation of the skin and subcutaneous tissue with interrupted sutures of fine silk completes the procedure.

SUMMARY

Some pertinent anatomical considerations relative to inguinal hernias are discussed.

A method of repair is described.

a



b

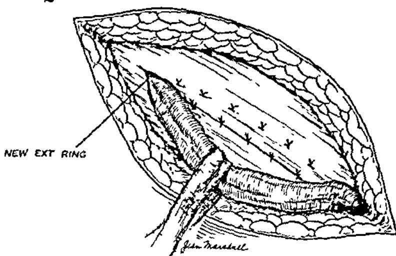


Fig. 509, *a*, The aponeurosis of the external oblique is being imbricated over the spermatic cord. This method of closure is preferable in small indirect hernias.

b, Imbrication of the external oblique beneath the spermatic cord, after the manner of Halsted, adds strength to the floor of the inguinal canal. This maneuver is employed in direct and in *large indirect hernias in which the transversalis fascia is disrupted.*

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SUBJECT INDEX

AUTHOR INDEX

Operative Surgery



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VOLUME I

Illustrations by Helen Lorraine

SIXTH EDITION

St. Louis

THE C. V. MOSBY COMPANY

1953

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This sixth edition is dedicated

to

the original author of this work

J. SHELTON HORSLEY, SR., M.D.

distinguished surgeon, author, and teacher
without whose inspiration and teaching
this edition could never have been accomplished

PREFACE TO SIXTH EDITION

The fifth edition of *Operative Surgery* was published in 1940, thirteen years ago. World War II started the following year and continued during the period in which a new edition ordinarily would have been published. Shortly after the war ended, Dr. J. Shelton Horsley, the senior author, died. Following Dr. Horsley's death it was thought for a time that it would be advisable to discontinue the book, for it was realized that his remarkable energy, broad surgical experience, and, above all, his mature wisdom would be sorely missed in the preparation of another edition. However, because of repeated requests from the publishers, The C. V. Mosby Company, and after one of us (G.W.H.) agreed to assume the responsibility of handling the details of the undertaking, it was decided to proceed with this, the sixth edition. It was obvious that the book would have to be largely rewritten, for the decade following the publication of the fifth edition had been one of remarkable change and progress in surgery. This progress was the result of a large number of factors, among them the occurrence of World War II. War has always stimulated new developments in surgery. Other factors, even more important than war, were the advent of the antibiotics, the development of satisfactory methods for storing blood, and, along with this, the belated appreciation of the necessity for the immediate replacement of blood lost during extensive operative procedures. Also of significance was the increasing appreciation of the necessity for more closely following the metabolic changes incident to illness and trauma, including surgical trauma. The first edition of this book, published in 1921, thirty-two years ago, called special attention to the importance of maintaining normal physiological balance and also dealt with those problems met with in general surgery and, in addition, certain conditions now cared for in the highly specialized fields of urology, orthopedics, and neurological surgery. Also included were procedures now handled almost exclusively by the plastic surgeons and other procedures in the province of the otolaryngologists. Yet the operations included in that edition were with few exceptions selected on the basis of a satisfactory experience with them by one surgeon. The same was largely true of the procedures presented in the second and third editions, published in 1924 and 1928, respectively. By the time of the publication of the fourth edition in 1937, the situation had changed so decidedly that Dr. Horsley felt it advisable to have an associate editor and also decided to include major contributions from specialists in neurological surgery, orthopedic surgery, and urology The section on plastic surgery was written by Dr. John S. Horsley, Jr., who, though a general surgeon, was particularly interested in reconstruction and reparative surgery.

Because of the tremendous scope of surgery today and also as a result of the aggressiveness of the surgical specialties, there has been progressive limitation of the field described as general surgery The authors believe that there is danger in

too high a degree of specialization and also believe it is necessary that surgeons be broadly trained, even though they may later choose to restrict their work to certain areas or systems within the body. Only by such restriction is one able to develop a high degree of proficiency in certain of the technics employed in special fields. With these considerations in mind, it seemed advisable to include a description of the commonly employed gynecological operations, for a large majority of such operations are performed by general surgeons. By the same token it seemed desirable to eliminate some of the more highly technical operative procedures employed in some of the special fields, notably in neurological surgery.

Because of the untimely deaths of John S. Horsley, Jr., and Donald M. Faulkner, the sections on plastic surgery and on orthopedic surgery had to be reassigned; plastic surgery to Dr. Henry J. Warthen, Jr., and Dr. Leroy Smith, and orthopedic surgery to Dr. M. J. Hoover. On account of the illness and retirement of Dr. C. C. Coleman, Dr. Charles E. Troland was asked to revise the section on neurological surgery.

We were fortunate to have Dr. A. I. Dodson again write the section on urology.

The gynecologic operations are ably described by Dr. Randolph H. Hoge.

A number of other surgeons were invited to make contributions on subjects in which they have developed particular interest and proficiency. We believe that their contributions add greatly to the value of this book. Their names and titles and their respective contributions are listed.

We were especially fortunate to be able again to have Miss Helen Lorraine make all of the drawings for this edition, and her beautiful and accurate drawings add immeasurably to this book.

We wish to thank all of our contributors who have given so unstintingly of their time and talent to make this edition an accomplished fact. The untiring efforts and encouragement of Mrs Daisy Spivey Fauntleroy in the careful preparation of the manuscript are gratefully acknowledged.

I. A. Bigger
Guy W. Horsley

Richmond, Virginia

PREFACE TO FOURTH EDITION

The fourth edition of this book is written under different conditions from those that existed when the first edition was published in 1921. Then I was working, at least to some extent, in urologic, orthopedic, plastic and neurologic surgery, as well as in so-called general surgery, and that edition was largely a record of my personal experience, with the addition, in instances where I had not performed certain operations, of described methods that appeared to me to be best suited for the lesion in question. In recent years, however, the specialties in surgery have become so distinct and aggressive that the general surgeon's field has necessarily contracted, while the specialties have become so elaborate that it would be impossible for any general surgeon to keep abreast with all of them. The methods of diagnosis in many of these specialties, as for instance urology and bronchoscopy, are now so complex that constant touch with them is required in order to be proficient in their use; and if a general surgeon devotes sufficient time to these methods of diagnosis to become really proficient in them, he must obviously neglect some portion of his work, as surgical pathology, which has a more direct bearing upon the fundamentals of general surgery. Therefore, regardless of the wishes of the general surgeon, much of the work previously done by him naturally gravitates to the various specialists.

Because of this condition, when the publishers requested a fourth edition of the *Operative Surgery*, I refused to undertake it unless I could have associated with me men who are well-qualified specialists and who could cover the fields that I attempted to cover in the first edition far better than I am capable of doing.

When this concession was made, I invited Dr. I. A. Bigger, professor of surgery at the Medical College of Virginia, to act as co-author of the book. Dr. Bigger has not only had extensive experience as a teacher in the Medical School of the University of Virginia and in the Medical School of Vanderbilt University before becoming head of the department of surgery of the Medical College of Virginia, but has done notable work in thoracic surgery as well as in general surgery. He is responsible for the chapters on surgery of the neck, thorax, breast, hernia, sympathetic nervous system, and some of the operations upon the extremities

The operations upon the pericardium, heart, and intrapericardial portion of the great vessels, especially those procedures indicated in the treatment of trauma to these structures, have been chosen by Dr. Bigger as a result of his considerable personal experience in this field of surgery. Usually the operations described are selected because he has found them to be satisfactory, but in some instances several operations for the same condition are given and no attempt is made to indicate the method of choice.

Dr. Bigger and I invited Dr. C. C. Coleman, professor of neurological surgery at the Medical College of Virginia, to write on the surgery of the central nervous system and the cranial nerves; Dr. A I. Dodson, professor of urology at the Medical College of Virginia and urologist to St. Elizabeth's Hospital, on urology; Dr.

John S. Horsley, Jr., assistant professor of surgery at the Medical College of Virginia and surgeon to St. Elizabeth's Hospital, on plastic surgery; and Dr. Donald M. Faulkner, orthopedic surgeon to Memorial Hospital and associate orthopedist to the Medical College of Virginia, on orthopedic surgery. Dr. Guy W. Horsley, who, though a general surgeon, is particularly interested in proctology, has given much aid in the preparation of the chapter on proctology. The assistance of others, for which we are grateful, is acknowledged in footnotes in the chapters in which their work appears.

This fourth edition follows the same general lines as the other editions and does not attempt to be an encyclopedic work. The methods described are those which either have been actually used by the author who writes of them or which seem to him to be the best for the lesion under consideration. Efforts have been made to base operative procedures upon physiologic function as well as upon anatomic structure and to retain physiologic function whenever consistent with the main object of the operation. For instance, in surgery of the stomach, a modification of the Billroth I method is described which we believe should be used in partial gastrectomy whenever possible, because the duodenum is the natural receptacle for the gastric contents.

Many new operative procedures are described which have not heretofore been published in a book, but none has been recommended which does not seem sound. At the same time such chapters as that on surgical drainage and on the underlying principles of the operations for malignant tumors have been retained. There are many new chapters, as the chapter on the surgery of acute abdominal conditions, and much of the work in the special fields has not heretofore appeared in any book.

Dr. Coleman, Dr. Dodson, Dr. John S. Horsley, Jr., and Dr. Faulkner have all included a number of new procedures in their various specialties, some of which are original with them.

Miss Helen Lorraine has very effectively added more than 500 new illustrations to this fourth edition.

The large amount of new material makes publication in two volumes necessary.

J. Shelton Horsley

Richmond, Virginia

I wish to express my appreciation to Dr. Horsley for allowing me the privilege of assisting in the revision of his book on Operative Surgery and for his generous help in this work.

I am glad to acknowledge my indebtedness to my associate, Dr. Harry J. Warthem, for his aid in correcting the manuscript as well as for his contribution on osteomyelitis. Miss Helen Lorraine has made beautiful drawings which add so much to a book of this kind My secretary, Miss Christine Provine, deserves especial mention for her care in preparing the manuscript.

I. A. Bigger

Richmond, Virginia

PREFACE TO FIRST EDITION

In this book particular stress has been laid upon the preservation of physiologic function and the interpretation of the biologic processes that follow surgical operations.

Naturally, a knowledge of anatomy is essential for operative surgery, but in many regions of the body an effort to conserve or to restore as far as possible the *physiologic function of the tissues involved in the operation* has often been neglected. Merely following anatomical landmarks and making a beautiful dissection with accurately placed ligatures and sutures should not be the sole aim of the surgeon. These things, of course, should be included in the surgeon's ideals, but it is even more important that the operation results in the extirpation or correction of the pathology, and in the restoration of the physiology of the tissues or organs. One of the chief aims of this book is to emphasize those physiologic and biologic principles which, to some extent, obtain in every surgical operation.

The biologic processes that follow the application of surgical drainage, for instance, have been too frequently not considered at all and surgical drainage has been regarded as solely or chiefly mechanical. The treatment of fractures by metal plates or screws produces excellent immediate mechanical results, but a little study of the biologic processes following the use of metal plates should convince the surgeon that this is not a satisfactory operation. Physiologic principles, if logically followed, in operations for ulcer of the stomach and for resection of the intestine, appear to lead to certain definite technics, even though others may be anatomically and mechanically unobjectionable. The development of collateral circulation around an aneurism by partial or intermittent occlusion of the artery, as has been practiced by Halsted and by Matas, is often a much safer procedure than the immediate and permanent occlusion of the vessel. Developing a blood supply in the pedicle of a flap by the gradual dissection of the flap in different stages, insures against gangrene and makes possible better plastic results because it brings more nutrition to the reconstructed tissues. There are many other examples that might be cited.

No attempt has been made to include in this volume all surgical operations. Such an encyclopedia of operations is found in many excellent textbooks and systems of surgery. Every operation that I have described is either one that I have done or else an operation that appears to me to be the one best suited for the disease. Frequently, conditions are such that different operations may be indicated for what appears to be the same affection. In order to meet this situation, I have often described several operations, each one of which I believe, under certain conditions, would be appropriate. In this way the book is to a considerable extent a record of my personal experience

All of the drawings are by Miss Helen Lorraine, except the illustrations of Dr. J. W. Long's enterostomy, which were drawn by William F. Didusch.

It is a pleasure to acknowledge my obligation to Mrs. A. C. Norris, my former secretary, who, in spite of her domestic duties, consented to help in the preparation of the manuscript for this book. She has greatly lightened the labor of its preparation.

My thanks are due Dr. W. T. Graham for many helpful suggestions about the sections dealing with orthopedic surgical operations.

J. Shelton Horsley

Richmond, Virginia

CONTENTS

VOLUME I

CHAPTER 1

CHAPTER 2

CHAPTER 3

CHAPTER 4

CHAPTER 5

CHAPTER 6

CHAPTER 7

CHAPTER 31

PAGE

CHAPTER 32

CHAPTER 33

CHAPTER 34

CHAPTER 35

CHAPTER 36

CHAPTER 37

CHAPTER 38

OPERATIVE SURGERY

VOLUME I

OPERATIVE SURGERY

VOLUME I

CHAPTER 1

GENERAL CONSIDERATIONS

Guy W. Horsley

A clear conception of the various technical steps is necessary for the proper execution of any procedure; but surgical operations are performed on living tissues and must be considered with regard to physiology and pathology in the living as well as from an anatomical point of view. Operations that look well on a cadaver will sometimes be unsuccessful on a patient. A beautiful operation that results in the death of the patient is not satisfactory surgery. While the mechanics of a surgical operation is important, it should not entirely dominate the situation. The object of a surgical operation is to save life, to relieve pain, and to restore function, and these three things in the order named should always be kept in mind. The technic of an operation should be chosen not solely because it appeals to a mechanical sense, but because it is biologically correct. The changes and reactions of tissues after operation must be borne in mind when selecting the technic for any surgical procedure.

It cannot be emphasized too often that surgery should be more a science than an art. A surgeon who is a dexterous operator and who skilfully amputates a leg that with patience and scientific application could be saved, is merely a good artisan, and is distinctly inferior to the surgeon who could save the leg even though he be a bungling operator. The ideal is to be thoroughly imbued with the principles of the biologic sciences, thoughtfully to apply these principles, and at the same time to be mechanically skilful.

The science of anatomy is essential to the mechanics of surgery. He would be a poor locomotive mechanic who did not understand the construction of his engine; and in operations on the neck, for instance, a surgeon who is ignorant of anatomy would be like the proverbial bull in a china shop. A knowledge of anatomy is essential to good surgery, but in the ever shifting problems of tissue repair and function, physiology is just as necessary. The principles underlying an operation are correct only if they conform to the laws of physiology and to the laws of repair of the tissue or organ that is affected. If we could get away from blindly

following what some one says merely because he says it, and do things because of reasons that have sound biologic foundations, we should undoubtedly do *work more* satisfactory to our patients and to ourselves.

Let us take an illustration from the practical work of a surgeon and see how thoughtful application of physiologic principles would have rendered a problem that appeared difficult easier to solve. Hyperemia is connected in one way or another with all surgical questions, whether they concern treatment of inflammation or repair of a wound. It has long been known that blood is an enemy of the tubercle bacillus, and that obtaining a good supply of healthy blood is a satisfactory method of combating tuberculosis. About four decades ago when a patient with tuberculous peritonitis and ascites sought surgical treatment he might have been subjected to one of several procedures. One surgeon would have advised opening the abdomen and letting the sunlight in; another thought it was best to dust the intestine with some special powder; still another believed in drainage with a single tube, or with multiple tubes. All these methods secured more or less satisfactory results. Each surgeon, seeing his patient recover after using his own method, thought that this was the only correct procedure. The situation resembled very much that described in a poem in an old school reader in which four blind men went to see an elephant. One fell against its side and thought the elephant was like a wall; another embraced a leg and declared it resembled a tree; the third grasped its tail and said the animal was constructed like a rope, and the last felt a tusk and concluded that the elephant was very like a spear. The moral was that though each was partly in the right they all were in the wrong. So all of these surgeons who were using different methods were unconsciously working on a principle that produced hyperemia, and it was this hyperemia, induced partly by draining off the fluid and so relieving pressure, and partly by handling the intestines, that cured the tuberculosis. It was many years, however, before this fact was acknowledged by the various partisans.

The surgical treatment of slow or threatened gangrene has also been much discussed Carrel and Guthrie, after two experiments, concluded that the blood circulation in the leg of a dog could be completely reversed within six hours. They severed the femoral artery and vein just below Poupart's ligament and united by suture the cardiac end of the artery to the distal end of the vein, and the distal end of the artery to the cardiac end of the vein. After a few hours, when red blood was seen returning, they assumed that the circulation was reversed. It can now be stated, however, that it is impossible to reverse the circulation in this manner. In a series of experiments which have been reported elsewhere, it has been shown that when the severed femoral artery and vein of an animal are sutured together in a reversed direction, there is no real reversal of the circulation, and the arterial blood never goes more than a short distance below the knee and is then quickly switched back to the iliac veins through the dilated collateral vessels. Evidently what happened in Carrel's experiments was that dissection and severing the vessels paralyzed the vasoconstrictor nerves, and the dilated capillaries permitted red arterial blood to flow through unchanged When the sciatic and crural nerves are divided in a dog, red blood appears in the femoral vein because of the extreme dilatation of the capillaries Clinically this is often seen to follow an application of the elastic tourniquet which, if left on for even a short time and then removed, produces an

intense flushing of the limb until the temporarily paralyzed vasoconstrictors have resumed their function. Many useless operations have been done attempting so-called reversal of the circulation in threatened gangrene. The only good accomplished, besides affecting the vasoconstrictors, was damming back the venous blood and forcing the small amount of arterial blood that reached the tissues to stay longer than it normally would, and so deliver to the tissues more nutrition than would be possible when the arterial blood was quickly drained off by unobstructed veins.

Surgery of the gastrointestinal tract not infrequently suffers from the lack of application of physiologic principles. Indeed, real progress in surgery of the stomach and intestines since the advent of the roentgen ray is more indebted to the observations of the physiologists and the roentgenologists than to the clinical work of the surgeon. We now know that the lesser curvature of the stomach is the portion that is physiologically active and initiates gastric peristalsis; that resection of a portion of the lesser curvature interferes very greatly with the subsequent movements of the stomach, and consequently causes disagreeable symptoms; whereas resection of a portion of the greater curvature which is apparently physiologically "silent" produces no such effect. The sensitiveness of the mucosa of the intestinal tract to acid from the gastric juice increases from the duodenum down to *and including the large bowel; so any direct communication between the stomach* and the intestine below the duodenum is always fraught with the danger of an ulcer if the acid of the gastric juice is high. This danger increases with the distance of the anastomosed segment from the duodenum.

There seems to be much to confirm the views of Cushing in assuming that certain persistently recurrent peptic ulcers are due to nervous influences, an imbalance between the sympathetic and vagus impulses to the stomach—more frequently a predominant vagus stimulant. Crile's work on the excessive stimulation from the suprarenal glands in producing peptic ulcer is also of interest.

A gastroenterostomy performed on a young man with peptic ulcer whose stomach has a highly acid gastric juice will probably be followed by jejunal ulcer. The frequent occurrence of peptic ulcer in the duodenum does not show so much a lack of resistance of the duodenum to the acid of the stomach, but that the mucosa of the duodenum is the first tissue to receive the full effect of the acid gastric juice ejected through the pylorus and so bears the brunt of its attack. If the sensitiveness of the duodenal mucosa to the acid gastric juice were as great as that of the lower ileum, for instance, we would probably all have peptic ulcer. In marked obstruction of the duodenum and dilatation of the stomach, when the acid in the gastric juice is not excessive, gastroenterostomy is often a very efficient and satisfactory operation.

In partial gastrectomy, particularly if done for peptic ulcer, it is usually advisable to follow the general principles of the Billroth I operation in which the stump of the stomach is anastomosed to the duodenum, the natural receptacle for the gastric contents. Many cases of jejunal ulcer following a type of Billroth II operation when the gastric juice acidity is fairly high have been reported. When, however, most of the stomach is resected as in a subtotal gastrectomy, thus decreasing the supply of gastric juice and hastening the emptying of the stomach, almost abolishing gastric function, the incidence of recurrent peptic ulcer is lower than when a less radical partial gastrectomy is done.

In surgery of the intestinal tract, the marked difference in the physiologic function between the small intestine and the large intestine should be borne in mind. Even the physiologic function of the upper small intestine differs considerably from that of the lower small intestine. In the upper small intestine where the peristalsis is rapid and the bacterial contents are low, the open methods of operation can often be undertaken safely, provided an ample lumen is made for the intestinal tract; whereas the same open methods without any preliminary preparation in the large intestine would probably be followed by sepsis and peritonitis. Not only is the bacterial content of the large intestine much greater than in the small intestine, but the blood supply is less abundant. In the large intestine itself the right side differs very much from the left side. In the right colon the feces is usually liquid, the absorption of fluid is rapid, and a lesion frequently results in production of marked toxic products which are quickly absorbed; whereas in the left colon the function is chiefly that of a reservoir.

There are many problems in neurologic surgery that require some knowledge of physiologic principles in order to be settled satisfactorily. Spiller and Frazier have demonstrated that section of the posterior sensory root of the gasserian ganglion produces what is called "physiologic extirpation" of the gasserian ganglion. It has been known for years that a nerve which is injured on the central side of its ganglionic cells does not regenerate; yet when the operation of division of the posterior sensory root for tic douloureux was suggested, it was received with some skepticism. This operation is safer than surgical extirpation of the gasserian ganglion, and is followed by less trophic disturbance. The plugging of foramina in the skull from which neuralgic sensory nerves have been removed in order to prevent regrowth of the nerves has sometimes been done with metal screws. Because an iron screw can stop a hole in a piece of wood is not necessarily a reason for employing it in living tissue On the other hand, some substance that does not cause reaction in bone is preferable. What happens after an iron screw is applied? Nature in an effort to extrude the irritating substance removes lime salts in its neighborhood, the bone softens, the screw becomes loose, and the nerve can grow around it.

The history of surgery of hydrocephalus contains many illustrations of the neglect of the appreciation of biologic principles in surgical operations. Various operations for this disease have been based upon an effort to secure drainage from the ventricles of the brain into the tissues of the neck with the idea that the excessive cerebrospinal fluid would be absorbed from this region. Tubes and threads of various kinds have been run from the lateral ventricle through the skull and into the tissues of the neck or scalp. There seems to have been very little consideration of how the absorption would take place after the mechanical features of the operation had been completed. It is obvious that a continuous injection of even a nonirritating fluid, such as salt solution, beneath the skin produces after a few days an exudate which, to a large extent, blocks the lymphatics and greatly retards absorption. When this takes place, it is only possible to cause the fluid to be absorbed by greatly increasing the pressure Such pressure, if produced in the brain, would be fatal from compression of the brain Consequently, even if the cerebrospinal fluid could flow unobstructed from the ventricles of the brain through a tube or along

threads into the neck, the intracerebral pressure necessary to force absorption would soon be so great as to impair the function of the brain.

That emotions have considerable bearing on the prognosis in certain cases of surgery has long been accepted. Cannon has demonstrated that fright or profound anxiety causes a stimulation, first of the sympathetics and then of the suprarenals. The action of epinephrine amounts to a prolonged stimulation of the sympathetic nervous system. Thus the body is put on what may be called a war basis: the circulation is more active, the heart beats faster, the pupils are dilated, respiration is accelerated, and metabolism generally is increased. Often there is so much glycogen released from the liver as to cause marked glycosuria, especially if the body is at rest; but if the emotions are accompanied by physical action, as fighting or running, this excessive amount of sugar may be consumed. The moral is that in some surgical cases it undoubtedly makes the prognosis better if emotions of fear or anxiety are allayed as much as possible. In diseases such as exophthalmic goiter, measures that abolish or diminish fear or excitement are of the greatest importance, and an operation should be so selected and performed as to carry out these indications.

Skin grafting and transplantation of organs or tissues are dependent on biologic laws. Surgeons who have had great experience in this type of work, such as Lexer and Davis, believe that skin grafts from others than the patient are practically never permanent. They either melt away at once, or, if they appear to "take," are later absorbed and replaced by connective tissue. It has been suggested that tests, as used for transfusion of blood, would be of benefit in selecting a donor for skin grafting; but even this has not seemed to have improved the end results. The transplantation of highly developed organs, such as a kidney, from one animal to another, even of the same species, is always a failure. The kidney may functionate for a while, but the fine biologic differences in the body fluids of the donor and the recipient cause degeneration, and the kidney eventually becomes a mass of connective tissue. This has been acknowledged by Carrel, Guthrie, and others who were at one time enthusiastic about the success of such a procedure. The reconstruction of channels, as the bile ducts, from tissues that have no resistance to the irritating discharges with which they must come in contact is also unwise. Operations in which strips of fascia, pieces of vein, and other tissue unaccustomed to the action of bile are used, ultimately result in failure, no matter how skilfully the mechanical part of the operation is done

These are merely a few instances of what every surgeon sees in his work, and they illustrate the profound influence that the application of biologic principles has on surgical practice Real progress in surgery lies not so much in cultivating the art of surgery and in striving after mechanical dexterity, which is important but can be acquired in a few years, as in the study of biologic principles that concern function, nutrition, metabolism, and repair of tissues, and in the thoughtful application of these principles to every operation and to every method of surgical treatment.

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CHAPTER 2

SURGICAL DRAINAGE

GUY W. HORSLEY

The biologic defenses of the body against disease, trauma, and the wear of age are wonderful, but they are not perfect If they were perfect, man would live forever. Particularly interesting is the manner in which the body protects itself against injurious foreign substances. The epithelium-lined body cavities have more or less specialized methods of protection The stomach, for instance, by vomiting, emits food that is spoiled and many drugs that are irritating or disagreeable to the taste and sometimes may reject substances that are thought to be nauseating or obnoxious even though they are not. The excessive salivation when nausea occurs probably tends to dilute the offensive material or to protect the walls of the mucous membrane. Vomiting undoubtedly is a habit that was acquired in the early days of evolution. The more refined drugs or poisons that are a result of chemical manufacture have not created a similar defense by the stomach and are often retained.

Foreign irritating substances in the rectum, the bladder, or the larynx are also expelled by muscular action. Irritating matter in the nose causes a profuse secretion, which tends to wash away the offending substance and may induce sneezing. An irritating foreign body in the eye causes a flow of tears in an effort to wash it away, and at the same time the spasm of the muscle of the eyelids is probably due partly to an attempt to expel the foreign body, as well as to protect against further injury.

In endothelium-lined cavities or in solid tissue there is an attempt to wash away foreign irritating matter. This is done by the pouring out of serum from the lymph circulation in the neighborhood of the foreign substance, which is accomplished by the reversal of the circulation in the local lymphatics, so as to empty their contents around the irritating material. This is really the chief basis of surgical drainage.

In surgical drainage mechanical measures that are followed by fortunate results would appear ridiculous if no biologic conditions existed. In preventing infection of a fresh raw surface, or in the so-called walling off of healthy tissue from the products of infection, gauze is often placed over the raw surface or as a coffer-dam in the abdominal cavity, and an abscess is drained through the center of this gauze packing. If we could convert this into a mechanical proposition and imagine that the pus was a solution of methylene blue and that it was flowing over this raw surface which had been covered with absorbent gauze to prevent contamination, we know that both the gauze and the wound would be deeply stained. This method of

protection, however, does act in a beneficial manner, and a clean wound is often by this means kept from septic infection. The drainage of a peritoneal abscess is practically always uphill and is usually successful. If mechanics were the only principle, how could an appendiceal abscess ever be drained by putting a tube down to it through the abdominal incision? The whole method of drainage really depends on the reversal of the circulation in the local lymphatics and is chiefly a biologic process. *It is nature's effort to extrude a foreign substance.*

A splinter in the finger which becomes mildly infected will provoke a discharge of thin seropus for days. This is nature's effort to expel the splinter. After it has been removed, the wound rapidly closes; and the lymph circulation, which was in part at least reversed in an effort to extrude the splinter, assumes its normal course, and probably twenty-four hours after the splinter has been removed there is no further discharge.

The peritoneum and its underlying structures in the abdominal cavity constitute an enormous lymph space, and the lymph is here abundantly poured out in response to an irritation. The insertion of a drainage tube causes a reaction in *which there is a flow of lymph in an effort to expel the drainage tube.* Drainage of the abdominal cavity prevents positive pressure in the septic region, and also the drainage tube is a stimulus for a reversal of the lymphatic circulation. The packing of a fresh wound with gauze causes a similar reversal of the lymphatic circulation; and though pus may flow over this gauze from a deeper focus, the lymphatics, instead of absorbing the pus, pour out lymph into and around the gauze to extrude it. The beneficial action of the cigarette drain, which is soon clogged with coagulated lymph, is comprehensible when we look on it as a stimulus for reversal of the local lymphatic circulation.

In regions of the body in which the lymph supply is less abundant than it is in the abdomen, unless the infected focus is very small it will be necessary to utilize gravity when instituting drainage, because there is not a sufficient flow of lymph to flush the septic cavity thoroughly and constantly, as there is in abdominal drainage

CLASSIFICATION OF SURGICAL DRAINAGE

Drainage in surgical operations may be classified under three heads:

1 Drainage of solid tissue or endothelium-lined cavities:

- (a) Drainage of endothelium-covered tissues of the abdominal cavity.
- (b) Drainage of other endothelium-lined cavities, as pleura, joints.
- (c) Drainage of solid soft tissue, as muscle, fascia, fat.
- (d) Drainage of bone.

2 Drainage of inflammatory products from infected epithelium-lined hollow viscera, as the gall bladder and the urinary bladder.

3 Drainage of hollow viscera in order to restore function or to secure physiologic rest

1. Drainage of Solid Tissue or Endothelium-Lined Cavities

Considering, first (1-a), drainage of abdominal abscesses, we find, as has already been stated, that the abdomen has an enormous supply of lymph and that the

successful drainage of an abscess in this region consists, first, of relieving the pressure in the abscess cavity by opening it and inserting a drain; and, second, of inducing a sufficient reversal of the lymph circulation by the presence of the drainage material to cause the septic products to be washed away along the drainage track. If the drainage material reaches the abscess cavity so that the pus is not under positive pressure, and if the drainage is sufficient in amount and of the proper kind to act as a stimulus for reversal of the lymphatic circulation, so much lymph is poured out that practically a continuous irrigation is going on from the local lymphatics along the tube or track of the drainage material, and it is a matter of but little importance whether the drainage material is pointed up or down. But in other endothelial cavities (1-b), such as the pleura or the joints, where the lymphatic supply is much smaller than in the abdomen or where the configuration is such as to make the drainage difficult, gravity must aid and the problem becomes more mechanical than biologic. Drainage here should be at the lowest point possible.

Drainage carried down to sutured bowel frequently results in a fistula, particularly if gauze in the form of a cigarette drain is employed The reversal of the lymphatic circulation in the neighborhood of a recently sutured intestinal wound, which will direct the current of lymph to the drainage, interferes with the normal process of repair in the intestinal wound, causes a weak fibrinous deposit, and diminishes the nutrition of the repairing bowel; consequently, the sutures readily break down and a fistula results.

In drainage of muscles, fascia, and fat (1-c), gravity drainage must be considered, but the biologic problem is also prominent. An abscess in the thigh heals better if gravity drainage is instituted. The drainage material should be sufficient not only to carry off the secretion but also to excite the local lymphatics to reverse their circulation. The local lymphatics, being much less abundant than in the abdomen, cannot usually furnish enough lymph to cause the flushing out of the septic products, as occurs in the abdomen. In rapidly spreading inflammation, wide incisions and drainage are useful in relieving the pressure that is made by the binding fascia or skin, and in reversing the circulation of the lymphatics and so preventing absorption of much of the septic products into the main lymphatic trunks.

The old operation of "fence rail" incisions along the margin of an advancing erysipelas causes the pouring out of lymph from these cuts and the diversion of the lymph current, which would otherwise carry the septic products to further uninfected regions. The undermining of the skin and insertion of tubes or gauze drainage from point to point make the pouring out of lymph along the drainage material even greater than after a simple incision.

That the reversal of the circulation of the lymph is the chief biologic process by which surgical drainage acts beneficially in solid soft tissue can also be recognized when there is a small abscess in a large amount of inflammatory exudate and it is impossible to locate the small abscess cavity. If a drain is placed in its immediate neighborhood, the abscess frequently opens into the drain. It seems probable that this occurs because the lymphatic current attempts to extrude the drain and so the products of the abscess are carried in this direction and the abscess burrows to the tube.

The drainage of tissues whose lymphatic trunks have been clogged and where, consequently, edema is present depends on an effort to increase the lymphatic circulation or to create new lymphatic connections. In the operation of Handley, in which long threads of silk are placed under the skin in edema of the arm, lymphatic channels form along the threads. In the operation of Kondoleon, the deep fascia of the arm or leg is split in order to promote an anastomosis between the deep and the superficial sets of lymphatics and so to divert the lymph current from the superficial to the deep lymphatic trunks.

Local edemas that are persistent are usually caused by blockage of the lymphatic channels and not by interference with the blood circulation. The edema that sometimes appears in the arm after a radical operation for cancer of the breast in which the axilla is thoroughly dissected is due to the removal of the lymphatics. If this immediately follows operation, it may disappear when the collateral lymphatic circulation is established; but when a late edema results, it is frequently because the lymphatics have become plugged with cancer cells; and such an edema is ominous. Resection of the axillary vein, if the lymphatics are in satisfactory condition, is followed by but little if any swelling in the arm, and that of a temporary nature. A phlebitis causes edema only when the lymphatics around the vein are involved in the inflammation.

Drainage of wounds after radical operations for carcinoma in solid tissue should always be done. This is not so much in order to carry off the fluids that may accumulate in the wound, as an effort to reverse the circulation of the lymphatics which may be induced to pour out their contents in the direction of the drainage tube and so to discharge, through this drainage, cancer cells that have been left in the wound or that may have lodged in the open lymphatics. This is *an important step in many radical operations for cancer, as after operations in the* neck or on the mammary gland.

Drainage of bone (1-d) involves problems of a somewhat different nature because of the structure of bone. Bone is compact, rigid tissue in which lime salts are arranged in an orderly way On account of the rigid structure it is impossible for either blood vessels or lymphatics to form, or for the lymph current to reverse, as readily as in soft tissue. Before drainage can be accomplished or any effective stand against infection can be made, the lime salts must be removed, so converting bone into what is practically soft tissue. For this reason in areas of inflammation bone is always soft Around an irritating substance in bone, whether accompanied by infection or not, lime salts are absorbed. When this is accomplished, the offending material becomes loose and is prepared for extrusion. If, for instance, a piece of iron, as a screw used in plating bone, is inserted into a bone, the lime salts in the neighborhood of the screw and of the plate are absorbed. The screws, which may have been very tight and firm when inserted, gradually become loose. This induced osteoporosis around the screws and the metal plate is just the reverse of what is desired when a fracture *is to be repaired, and it accounts for the frequency of* nonunion after the plating of bones

The numerous so-called abscesses at the roots of teeth are probably often the result of the reaction of the bone in the neighborhood to some material that was used in filling the cavities in the roots of the teeth. Undoubtedly apical abscesses

frequently occur, but it is probably equally true that an osteoporosis sometimes interpreted as an apical abscess may be sterile and due to the reaction of the bone to the material with which the root of the tooth has been filled.

2. Drainage of Inflammatory Products From Infected Epithelium-Lined Hollow Viscera, as the Gall Bladder or the Urinary Bladder

Drainage here involves principles different from the drainage of an abscess that has formed in solid tissue. This drainage is not only for removing the products of infection but serves a double purpose in also giving physiologic rest to the infected organ. The drainage of a septic gall bladder that may be filled with pus carries off the products of the bacteria and at the same time gives rest to the gall bladder by preventing distention, and this removes both a stimulus for contraction and the tension that would occur on the distended walls. Drainage of this type does not have to be gravity drainage. If a sufficient opening is provided in the general axis of the peristaltic current, it is all that is necessary. In draining an infected urinary bladder, for instance, an opening made at the top of the bladder is as satisfactory in securing results as an opening at the bottom.

When these hollow muscular organs are contracted, a small opening will insure the viscera's keeping empty if it is made in due regard to the action of peristalsis. Even in such instances, however, the beneficial action of the drainage is not solely the removal of the contents of the hollow viscera or the giving of physiologic rest. It seems highly probable that reversal of the lymphatic current is also of importance here. This appears to be borne out by the results of drainage of the bile tracts in inflammation of the pancreas. It is well known that chronic pancreatitis can best be treated by prolonged drainage of the bile tracts; and drainage of the common bile duct for this affection seems to be particularly effective. The work of Deaver and Pfeiffer on pancreatic and peripancreatic lymphangitis is interesting in this connection They call attention to the anatomy of the lymphatic supply of the pancreas and its ultimate connection with the lymphatic supply of the bile tracts and gall bladder.

If infection of the pancreas can be through the lymphatic supply from the gall bladder or the bile tracts, as Deaver and Pfeiffer assert, it seems that the method of relieving this infection is to reverse the lymphatic current and cause it to be diverted toward the drainage tube and the incision in the gall bladder or in the common duct, just as the lymph flow is reversed in the drainage of an abdominal abscess. Septic products that would be carried in the lymphatics from the infected gall bladder to the pancreas are thus diverted to the drainage tube in an effort to extrude it. If this diversion can be maintained sufficiently long to permit nature to build up the resistance of the pancreas to the infection and repair the damage already done, the patient may be considered cured. But if the drainage tube is removed too soon, there is no further stimulus for a reversal of the lymph circulation, and the pancreatitis recurs.

Too early resumption of function after drainage of inflamed hollow viscera frequently results in a *recurrence* of the inflammation. This may be due to one of three causes, or more probably to a combination of three causes: (1) There may

Combinations that are effective have been worked out to a large extent empirically. Sometimes strands of catgut, silk, or strips of rubber tissue are inserted into a wound in which it is anticipated that there may be a collection of serum or broken-down fat on account of the nature of the wound. This foreign substance, the drainage material, directs the current of the lymphatic flow toward itself and so prevents an accumulation in the tissues which might later become a culture medium for bacteria. An open superficial abscess often needs no drainage material, for the necrotic products of the inflammatory process are a sufficient stimulus for drainage.

ENCAPSULATED FOREIGN BODIES IN THE PERITONEUM

If such foreign materials as gauze or cork are left in the abdominal cavity under sterile conditions, they are rapidly surrounded by a deposit of fibrin, as shown by Hertzler. This fibrin, which is coagulated lymph, soon is covered with endothelium and takes on the characteristics of peritoneum If the gauze is left for a number of weeks or months, it may intrude into a neighboring hollow viscus and be expelled, as this may be the point of least resistance, and, consequently, of greatest pressure. Instances are recorded in which gauze that has been accidentally left after a surgical operation has been expelled by the bowel or by the bladder months or years later. Sometimes, however, the gauze is completely encapsulated with a cystlike wall and becomes so thoroughly infiltrated with fibrin that partial organization takes place. Portions of the gauze may be disintegrated and removed by phagocytes, and the connective tissue penetrating the rest of the gauze is so intimate that it may have to be dissected away with much difficulty.

CRITICISMS

The phrase "reversal of the lymph circulation" may not have been happily chosen, but we know no other that would be quite as satisfactory. The impossibility of an extensive reversal of blood circulation is fully appreciated, and it has been shown that a vein and its contributing branches would not function as an artery when an arterial current is turned into the vein.

Surgical drainage is not a physiologic but a pathologic process. Lymph or serum is continually poured around an offending foreign body until the foreign body is removed or encapsulated This lymph comes partly from the injured lymph channels and lymph spaces in the tissues and partly through the uninjured walls of the lymph channels which become more permeable with the hyperemia that is present when surgical drainage is necessary.

These are facts that are largely self-evident. The moot point is whether this process can be called reversal of the lymph circulation This phrase was used because it seems that the current of lymph or serum continually poured out to the surface of the skin for days or weeks constitutes in a sense a circulation of lymph. This current, if it rises to the surface of the body and appears on the skin or mucous membrane, is not in the direction of any known lymph current and probably is a reversal, or at least a deflection, of the direction of the adjacent normal lymph currents. Then, too, this phrase seems to emphasize a phenomenon that many surgeons apparently ignore.

be an accumulation of secretion that is not free from the products of the inflammatory process. (2) There is an interruption of physiologic rest. (3) There is a change in the lymph current from that which has been instituted by the drainage.

3. Drainage of Hollow Viscera for Physiologic Rest

In enterostomy, the operation may be done to sidetrack the normal contents of the hollow viscera and so to afford less work for the diseased tissue below the point of opening, as in colostomy for disease of the large bowel farther down. Drainage may be instituted to prevent distention of a hollow viscus and so induce rest in order that an operative wound may heal. This principle is put into practice in such operations on the bladder as for vesicovaginal fistula when a self-retaining catheter is placed in the urethra, and in the introduction of a tube through the rectum and through the site of resection of the sigmoid or left colon in order to draw off the gas and prevent distention in the region of the operation. This principle of drainage is employed when a gastric tube is inserted through the nose after operations on the stomach.

DRAINAGE MATERIAL

The material for drainage must be considered not only with regard to transporting what is to be drained, but also with regard to the biologic influence of the drain on the local lymphatics. Certain substances produce a more pronounced flow of lymph than others. Rubber, for instance, is not so irritating to tissue as gauze. When gauze is placed over a raw surface, the local lymphatics pour into the gauze quantities of lymph. This is nature's effort to extrude an irritating foreign substance. When the lymph has coagulated, the meshes of the gauze become entangled with the wound, and an effort to remove the gauze before this fibrin has softened results in tearing the delicate tissues of the wound and injures its granulations, causing bleeding. An ideal drainage material would be one which, on the one hand, is a pronounced stimulus for the lymph to be poured out along the drain and, on the other hand, would not be sufficiently attached to the raw surface of the wound to injure it. This material has not yet been found.

Rubber drainage tubes are frequently used, and have the advantage of draining off inflammatory products readily; but they do not provoke such an outpouring of lymph as gauze would. Naturally, however, the larger the tube, the greater the irritation and the more pronounced the stimulus for a reversal of the circulation of the local lymphatics. Consequently, for draining an abdominal abscess, it is often found that a large tube does better than a smaller one, not because the smaller one is insufficient to carry off the serum or the pus, but because the small tube is not large enough to provoke a sufficient amount of reaction among the local lymphatics. Frequently the advantages of both gauze and rubber are combined by placing a gauze strip inside the tube or by wrapping strips of gauze in rubber tissue or rubber dam, which is called a "cigarette drain," and using this in addition to a tube. In this way the gauze which is exposed at the end of the cigarette drain causes a more pronounced flow of lymph than the rubber tube alone could produce, and the tube drains away the lymph that is thrown out to extrude the gauze and the tube Drainage material should not remain too long in a wound, else it will act as the infected splinter mentioned above

CHAPTER 3

TECHNIC, SUTURES, AND INSTRUMENTS

Guy W. Horsley

The technic of an operation refers to the mechanical steps of the procedure and also to the manner in which the operator and his assistants execute these steps. Before the institution of antiseptic surgery, and particularly before general anesthetics were introduced, the time consumed in performing the operation and the style in which the operator worked were considered extremely important. Naturally, with a suffering patient without an anesthetic it was highly desirable to complete the operation as soon as possible. It was also found in preanesthetic days that a quick operation was usually more successful than one that was prolonged. In order to operate as quickly as possible, certain movements, methods of holding the knife, and of securing vessels, were considered good form, without which the proper speed could not be obtained. This is similar to athletic games, as in tennis, golf, or baseball, where the tennis racket, golf stick, or bat must be held in such a position or swung in a certain manner in order to secure the approval of experts on form.

When the surgeon made a practice of washing his hands only after the operation, and when instruments, hands, and everything that came in contact with the wound were loaded with bacteria, naturally the quicker the operation was done the better it would be for the patient, because the longer the wound was exposed to the septic hands of the surgeon or to the infected instruments or sponges, the greater would be the infection. Quick surgery in such instances was justly considered a vital necessity. There is not the same demand, however, for speed since the development of anesthetics and aseptic surgery. It is infinitely more important to do a clean operation gently than it is to do a rough operation quickly. The operation should be completed, however, as soon as is consistent with thoroughness, gentleness, and the complete application of the principles of aseptic surgery. The recent advent of chemical and antibiotic substances, which have done much to control and reduce infections, should in no way lessen the importance of gentle and meticulous aseptic surgical technic.

The instruments used should, of course, be such as may be needed in the performance of an operation, but effort should be made to use no more instruments than are necessary. Special instruments always carry the necessity of proving their worth. If an operation can be satisfactorily done with a sharp knife and sharp scissors and careful manipulations, there is no real need for special instruments, even though some surgeons require them. It is essential to have instruments that are reliable and of good quality. It is not only provoking to the surgeon to have a

It may also be objected that "lymph" is used in rather a loose sense. It has been employed as indicating the thin, clear fluid that is found in the lymph channels and spaces of the body and that infiltrates the tissues in edema. In order to describe the phenomena of surgical drainage it appears to be necessary to use the words "lymph" or "serum" to indicate such fluids.

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strands are absorbed or encapsulated. Many surgeons, however, find that for buried sutures or ligatures absorbable material is, in the end, more satisfactory.

In plastic work catgut is not the ideal suture material. Its tendency to cause considerable reaction during the healing of tissues makes more exudate and frequently results in a more conspicuous scar than when nonabsorbable material, such as fine silkworm-gut, nylon, silk, or horsehair is used. There is not the same excuse for using catgut on the surface of the wound, where it can be easily removed, as when a suture or ligature must be buried. Fine plastic work on the skin, where an inconspicuous scar is desired, calls for nonabsorbable sutures.

When catgut is used in buried sutures, the smallest strand that will do the work should always be selected. For ligating most bleeding points, 00 plain catgut is sufficient. It must be remembered that catgut is absorbed, and the larger the strand the greater the burden of absorption placed upon the tissue. In addition to this, a fine strand of any material holds the knot better than a coarse strand. There is less likelihood of the knot slipping in a fine strand because there is more friction, due to greater surface compared with cubical contents in the smaller strand. It is better to use two fine strands of catgut than one large one, because they can be more readily absorbed. It is important in all sutures not to tie the knot too tightly as this constricts tissues unduly. This is particularly true of catgut.

Besides plastic work, special suture material is indicated in special regions Marion Sims' well-known experiments showed that silver wire was the only material with which he could satisfactorily repair a vesicovaginal fistula. This is not only because it can be easily handled and nicely adjusted, but because metallic silver itself is mildly antiseptic and has no capillary action. Improved aseptic methods permit other suturing material to be used in repairing these fistulas, but the lesson taught by Sims is frequently neglected.

For bone, stouter suturing material must be used Some have recommended heavy kangaroo tendon, but with the mechanical friction from the sharp edges of bone these tendons may not hold long enough. Moderately stout wire, particularly a cable of fine tantalum wire, is especially suited for work on bone, though where the strain is not great, tendon or chromic catgut is satisfactory.

When through-and-through sutures are used in the abdomen nonabsorbable material should always be employed. Silkworm-gut, nylon, or silk is excellent here, though silver or stainless steel wire is used by many surgeons and has the advantage of being mildly antiseptic.

Various methods of closing abdominal incisions and other skin wounds are shown in Fig. 1.

For suture material in the intestines, cotton or silk is satisfactory, though some surgeons use catgut. The nonabsorbable suture seems to be extruded into the lumen of the intestine and rarely, if ever, causes trouble. If a single line of sutures is used in operations upon the intestine, and catgut is employed, it may be absorbed too soon and perforation may result. This is because in order to secure a firm hold in intestinal suturing it is necessary to catch the submucous coat or to penetrate into the lumen of the intestine Where the suture penetrates into the lumen the rate of absorption of catgut would be so rapid as probably to be unsafe unless the catgut was chromicized to such an extent as to make it practically a nonabsorbable suture.

dull knife and dull scissors, but it is unfortunate for the patient. In dissections, particularly around large vessels, dull instruments are dangerous, because undue effort has to be made with dull instruments to divide tissues when merely a gentle stroke of a sharp knife is all that is necessary. Consequently, the force and direction of the cut with a dull knife or scissors cannot always be as accurately gauged as with a sharp instrument. At one time it was fashionable to have forceps and scissors constructed with so-called aseptic locks, so they could be taken apart easily and cleaned. Such instruments frequently fell apart while they were being used and the joints soon permitted such play as to make the instruments undependable

Suture or ligature materials are used in almost every operation. There is great difference of opinion as to choice of suture material and much is left to the individual surgeon's judgment. The sutures usually employed are silk, cotton, silkworm-gut, nylon, horsehair, catgut, kangaroo tendon, silver, tantalum, stainless steel, and bronze wire. There are certain operations in which there is almost unanimity of opinion among surgeons as to the type of suture material to be used In most instances, however, the difference of choice is marked. Many operators use catgut for almost everything The former objection to catgut, that it could not be properly sterilized, hardly exists today. It is true that sterilization of catgut is more difficult than sterilization of the nonabsorbable suture materials which may be boiled. By elaborate processes and repeated sterilization, however, catgut can be made entirely safe from the standpoint of sterility. Its rate of absorption can also be regulated to some extent by the size of the strand used, but particularly by impregnating the catgut with chemicals that make it resist absorption. The most used chemical is chromic acid products. By regulating the strength of the solution and the time during which the catgut is exposed to the solution, varying rates of absorbability are obtained. These rates, however, are not entirely accurate. The chief objection to catgut these days is that it is irritating to the tissues, particularly when impregnated with chemicals, and causes more reaction than do nonabsorbable sutures. If the catgut is not impregnated with some antiseptic it soon becomes a culture medium, and if the wound has been contaminated or if there is a hematogenous infection, the catgut may be the center of suppuration. When catgut is used in the mucosa of the gastrointestinal tract, it is, of course, rapidly absorbed, but if it is buried by successive layers, properly selected and applied, it will hold a sufficient length of time for union to take place. It has an advantage in operations upon the stomach, in that it is in the course of time completely absorbed if not too strongly chromicized, whereas if silk or cotton is used it is extruded toward the lumen of the stomach and sometimes becomes entangled in the mucosa and forms a source of infection and continued irritation. In the vaginal mucous membrane catgut is not absorbed so quickly as in the gastrointestinal tract, but much more rapidly than in skin or muscle.

Nonabsorbable sutures when buried often give trouble. It is not uncommon for sinuses to occur months after operations, when buried nonabsorbable sutures are used, and these sinuses will not heal until the sutures are removed If nonabsorbable sutures are employed, the smallest strands that can safely be used should be chosen The larger the bulk of material, the greater is the likelihood of trouble and sinus formation When very fine silk is used to tie vessels and the aseptic technic is perfect, no trouble may result from the nonabsorbable suture, and in time such fine

One of the most important procedures in the technic of surgery is tying knots. This can be done by any method that the operator finds best suited to his individual requirements. The all-important point, as taught by the old authorities, of making every knot a reef or flat knot has been greatly exaggerated, but undoubtedly a reef knot does hold better than the so-called "granny knot" (Fig. 2). The surgeon's knot consists of a double turn in the first tie and a single turn in the second. The double turn in the first tie secures the thread so that the second tie can be run down without the first slipping. The fallacy in this, however, is that when two wraps or turns are made instead of one, it is more difficult to run the first tie down smoothly and it is hard to tell how much pressure is being made on the tissues and how much is being taken up by the extra friction of the double wrap. In order to secure accuracy in tying large vessels or in mass ligatures it is much better to make merely a single wrap, as in the reef knot, and while this is tight, have it held firmly with a mosquito hemostatic forceps, which is strong enough to prevent the tie from slipping and at the same time is not strong enough to injure the thread. The second tie can then be run down easily. In any important suture or ligature it is best to make three ties to the knot instead of two. Then the knot will hold whether it is a "granny" or a reef knot.

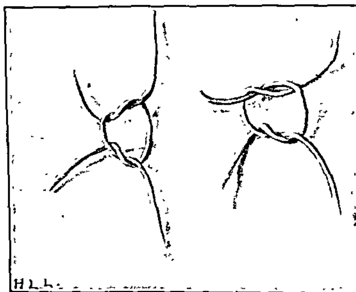


Fig. 2.—Reef or flat knot, and "granny" knot.

In making a knot it is well to cultivate the art of tying it with one hand, as it frequently saves time and suture material. The finer the strand used for suture or ligature the more likely is the knot to hold, because there is more friction as the surface of the fine strand is greater in proportion to its cubical contents than in the coarser strand.

The reef knot lies flat because the loop on each side is over both strands of the thread. The tying of the reef knot can be best accomplished by concentrating the attention on one end of the thread and disregarding the other. If the first tie of the knot is so made that the right end lies away from the operator, the same end should then loop over the left end in the second tie in such a manner that it crosses the left end from above downward and toward the operator, and then passes

The thick walls of the stomach permit the use of catgut when there are several layers of sutures and when at least one of these layers is *not in contact* with the mucosa.

In large ventral hernias or in recurring inguinal hernias, a suture of fascia lata taken from the patient, according to the method of Gallie may be used. A strip of fascia can be utilized in the large needles as a continuous suture or an interrupted suture, or woven back and forth after the manner of a cobbler stitch or so-called basket weave. This suture should be reinforced by interrupted sutures of kangaroo

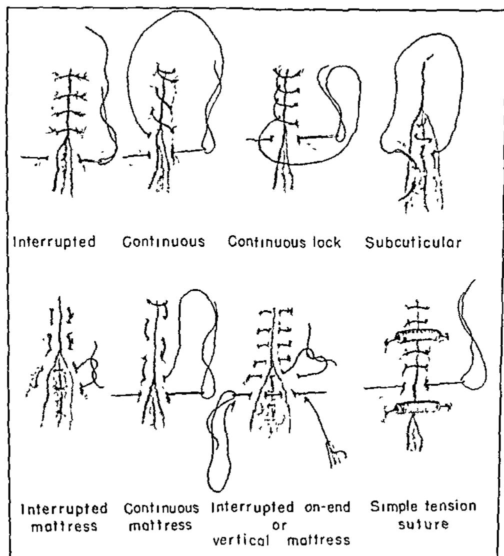


Fig. 1 —Various methods of closing abdominal incisions and other skin wounds.

tendon or silk at intervals. The suture is obtained from the outer surface of the fascia lata of the thigh, either by a long incision or else by two short incisions, one above and one below, the strips being pushed down by a special instrument, or sometimes the loop of a small uterine curette will suffice. The strips are tied in the Gallie needle with silk or catgut. Two strips are united by tying the two ends firmly together with fine silk and then transfixing the ends with a suture of silk and again tying it. This gives a long strip of fascia lata with a needle at each end, which can be woven back and forth to cover the defect

One of the most important procedures in the technic of surgery is tying knots. This can be done by any method that the operator finds best suited to his individual requirements. The all-important point, as taught by the old authorities, of making every knot a reef or flat knot has been greatly exaggerated, but undoubtedly a reef knot does hold better than the so-called "granny knot" (Fig. 2). The surgeon's knot consists of a double turn in the first tie and a single turn in the second. The double turn in the first tie secures the thread so that the second tie can be run down without the first slipping. The fallacy in this, however, is that when two wraps or turns are made instead of one, it is more difficult to run the first tie down smoothly and it is hard to tell how much pressure is being made on the tissues and how much is being taken up by the extra friction of the double wrap. In order to secure accuracy in tying large vessels or in mass ligatures it is much better to make merely a single wrap, as in the reef knot, and while this is tight, have it held firmly with a mosquito hemostatic forceps, which is strong enough to prevent the tie from slipping and at the same time is not strong enough to injure the thread. The second tie can then be run down easily. In any important suture or ligature it is best to make three ties to the knot instead of two. Then the knot will hold whether it is a "granny" or a reef knot.

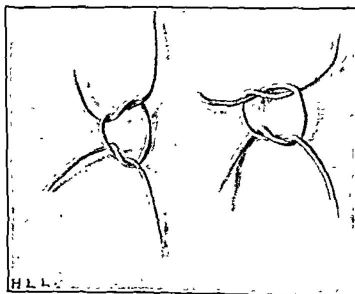


Fig. 2—Reef or flat knot, and "granny" knot

In making a knot it is well to cultivate the art of tying it with one hand, as it frequently saves time and suture material. The finer the strand used for suture or ligature the more likely is the knot to hold, because there is more friction as the surface of the fine strand is greater in proportion to its cubical contents than in the coarser strand.

The reef knot lies flat because the loop on each side is over both strands of the thread. The tying of the reef knot can be best accomplished by concentrating the attention on one end of the thread and disregarding the other. If the first tie of the knot is so made that the right end lies away from the operator, the same end should then loop over the left end in the second tie in such a manner that it crosses the left end from above downward and toward the operator, and then passes

through the loop made by the left end. If this can be borne in mind, a flat or reef knot will always result, but even then, it might be wise to make a third tie.

Grant has described an excellent method of rapidly tying a knot with forceps so that the thread need not be touched with the hands, with great saving of suture material. If the operator wears good rubber gloves, there is no objection, from the

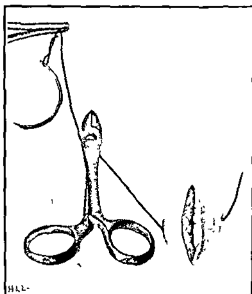


Fig 3.

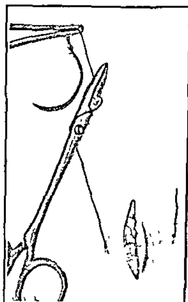


Fig. 4.

Fig 3.—Grant's method of tying knot with forceps The suture has been passed and forceps laid to the right of the thread.

Fig. 4—Forceps have made a loop in the thread, with the nose of the forceps up

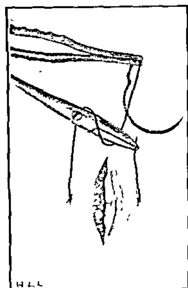


Fig 5.

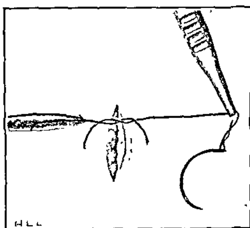


Fig 6

Fig. 5—The tip of the thread is grasped with forceps.

Fig 6—The thread is pulled through, forming the first tie of the knot

standpoint of asepsis, to tying the knot with the hands, but not infrequently when there is a short end it can be tied more accurately and more quickly by this method of Grant than with the fingers. It is also useful for tying in deep cavities where

the fingers or hands cannot readily reach (Figs. 3, 4, 5, 6, 7, 8, 9, and 10). The technic as described by Grant is as follows:

If the knot is to be tied in a transfixion suture or ligature, first transfix the tissues with the needle, which must be *pulled through with the forceps, and catch* the suture near the needle with forceps in the left hand. Pull on the thread until

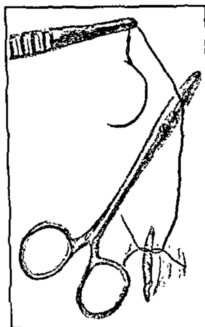


Fig 7

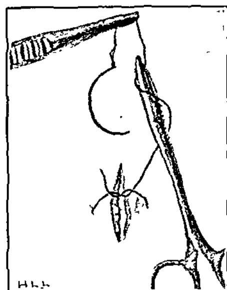


Fig. 8.

Fig. 7—The second loop is made with forceps, this time with the forceps to the left on the under side of the thread

Fig. 8.—The loop has been completed.

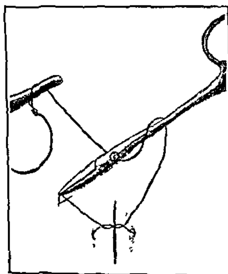


Fig. 9.

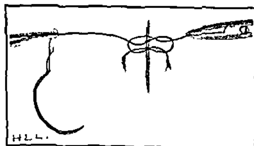


Fig. 10.

Fig. 9.—The tip of the thread is drawn through

Fig. 10—The second tie of the knot is completed, making a reef knot

the right-hand short end is only about 1.5 cm. long The long end should be proximal and the short end distal to the operator. Lay the point of the needle holder across and on top of *the suture just below the point* where the suture is being

held with thumb forceps pointing upward toward the tip of the thumb forceps, and make a loop as shown in the illustration. Then catch the short end of the suture with the tip of the needle holder and pull the short end through the loop while the left hand holds the long end of the suture taut with the thumb forceps. Next place the needle holder *beneath* the suture and make a second loop, catching the short end as before. This always results in a reef or flat knot.

Knots can be tied quickly in this way, with short ends and with a minimum amount of material They can also be made in cavities in which it is difficult or impossible to use the hand or fingers.

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CHAPTER 4

PRINCIPLES UNDERLYING OPERATIONS FOR MALIGNANT TUMORS; TECHNICAL CONSIDERATIONS IN OPERATIONS FOR MALIGNANCY; X-RAY AND RADIUM BURNS

GUY W. HORSLEY

In order to have a clear conception of the surgical treatment of malignant tumors it is necessary to be acquainted with the essential facts known about them. A surgeon may not care to be his own pathologist in every instance, but he should at least take a sufficient interest in the tissue that he removes to study its histologic structure The surgeon will thus have rich opportunities for the understanding of tumors. Other things being equal, a surgeon personally acquainted with pathology is more competent to operate upon cancer than one who is not. Besides, there is nothing more interesting than to view the microscopic structure of a doubtful tumor. This stimulates the scientific possibilities of surgery and prevents the operator from being merely a "cutter."

A fatal technical error in suturing the intestine or in obtaining hemostasis may be directly traceable to the operation; on the other hand, the surgeon who does not recognize a malignant growth of the breast and operates upon it as though it were a benign tumor, making an incomplete removal, is just as responsible for this error which causes the patient's death months or years later as he who inserts a faulty intestinal suture. The lack of knowledge of pathology is just as fatal as his technical incompetence in performing an operation. The patient who dies from a recurrent cancer that might have been prevented by the application of knowledge of pathology is just as dead as one who perishes because of bad mechanical technic at the operating table.

Operations for malignant tumors occupy a prominent place in surgical practice. The great increase in the incidence of cancer makes surgery for the relief and cure of neoplasms more important than ever.

Various causes have been suggested to explain this increase in cancer. One of the most prominent is the prolongation of life. The average expectancy of life is now about seventy years, and this increase has been chiefly from the decrease in the mortality rate of infants and children and of infectious diseases. A large part of this decrease is due to the work of public health services in the prevention of diseases such as malaria and typhoid, and in controlling epidemics. This decreased mortality in the young throws more individuals into what has been termed the "tropic of cancer," for cancer is pre-eminently a disease of middle and old age.

Dublin, of the Metropolitan Life Insurance Company, estimates that we may look forward to an increase in cancer rate for many years, as more individuals are reaching this "tropic of cancer" from the lessened mortality in children and early adult life. Then, too, more accurate diagnoses doubtless have something to do with the apparent increase in the incidence of cancer. Better pathologic diagnosis and more frequent postmortem examinations undoubtedly uncover many cases of cancer that were formerly otherwise classified. It will usually be observed that in populations in which the postmortem examination rate is low, cancer incidence is also low, and in areas in which the postmortem examination rate is high, the incidence of cancer seems to have increased. That careful examination and thorough necropsies will show more cancer seems to be a fact. But after making all due allowances for these two causes, there still appears to be an increase in the death rate from cancer that is difficult to explain.

Cancer, to be sure, is chiefly a disease of middle or old age, but it is not solely confined to these ages. Frequently sarcoma, a malignancy of connective tissue or of bone, attacks infants or children. While the death of little children has a more sentimental appeal and is justly held in high regard in the battle for the prevention and cure of disease, the middle-aged and elderly should also be considered. Frequently the death of a well-trained individual in the full tide of usefulness is both an economic and a civic loss.

THE CAUSE OF CANCER

Much has been said about the futility of cancer research: that after concentration on this problem for years in some of the best laboratories in the world the cause of cancer has not yet been discovered. In a sense this is true, but it should not be necessarily considered a crushing objection. Even in some of the acute infectious diseases, such as smallpox, which, certainly from a preventive standpoint, are treated effectively, we do not know the cause of the disease, and in those instances such as tuberculosis and diphtheria in which the etiologic relationship of bacteria has been proved, we are unaware of the cause of the bacteria; so we have merely gone in etiology one biologic step and have come up against a blank wall.

Cancer, like life, is somewhat difficult to define. Like life, too, we are generally aware of what it is: that it consists of an aggregation of cells springing from the tissue in which it arises, growing without law and order, and with an intrinsic tendency to destroy life It is not contagious or infectious and is almost always painless in the early stages. It was formerly held that cancerous tissue was without any physiologic function, but now we know that malignant tumors of the liver may actually secrete bile, that cancers of the thyroid will produce some of the thyroid internal secretion, and that malignant tumors of the adrenal gland stimulate sex changes. The search for some definite microorganism of cancer from which all cancers may originate has been rather definitely abandoned by most pathologists. It seems to be accepted that cancer doubtless springs from many causes and has various biologic etiologies.

The rôle of heredity in the causation of cancer has attracted much attention. Little, in 1923, examined the family histories at the Eugenics Record Office of the Carnegie Institution at Washington, and became convinced from a study of these data that there is an hereditary predisposition toward carcer J. A. Murray,

Tyzzer, Loeb, Slye, Lynch, Marsh, W. S. Murray, and others seem to have shown that genetics play an important part in influencing the incidence of cancer. Maude Slye has accumulated a wealth of material demonstrating that hereditary traits in mice profoundly affect cancer. According to Little, however, she has placed a wrong interpretation upon these facts, believing in a single simple mendelian unit which is recessive in inheritance to the noncancerous type; whereas the work of Lynch and of Little and his associates appears to show that while the hereditary influence is marked, it is not due to a single mendelian unit but to several factors and that it tends more to become dominant than recessive. This latter view seems to be substantiated by experiments with inoculated cancer in which the resistance to inoculation of cancer may be transmitted as a result of several different factors. Cancer, then, appears to arise chiefly in individuals who have inherited a lack of control of cells of the tissues, and in certain organs this control is more marked than in others. This lack of control may reside in the cell itself or in its environment. It is well known that cancer of the lips and face occurs much more frequently than cancer in the skin elsewhere. Cancer of the stomach is one of the chief causes of the deaths from cancer, while cancer of the adjoining viscus, the duodenum, which is more subject to ulceration than the stomach, is extremely rare.

Breaking away of cells from tissue control seems to be an important item in the initiation of cancer, and irritation which induces repair and consequently calls for a larger number of new cells than would otherwise be needed increases the chances for the cells to break away from control. In stabilized tissues, such as the palms of the hands and the soles of the feet, which have been stabilized by use and by repeated traumas during evolutionary times, control of the cells is so marked that even with numerous irritations primary cancer almost never appears.

But this breaking away of cells from control is not fully understood. Just what this control consists in is not well known. Merely severing the nerve connections in the tissues is not sufficient. Ewing has called attention to the fact that in artifical culture of normal cells, the cells practically never become malignant, and it is obvious that cells growing in artificial media would be without control from any surrounding tissue. Doubtless this lack of control from surrounding cells or tissue must be accompanied by some intracellular change and lack of control in the cells themselves, for otherwise it would seem that in an artificial culture of normal cells, there would be an ideal condition for the beginning of cancer, if lack of control from the adjoining cells were the essential and only factor.

CANCER RESEARCH IN THE LABORATORY

Cancer research work and the study of experimental cancer have taught us much about the nature of this disease. Ewing summed up very concisely the results of cancer research. First of all, he called attention to the unintentional production of cancer in their own persons by the early workers in x-ray. The squamous cell type of cancer of the skin and angiosarcoma in granulation tissue have been produced by this radiation in man and in the lower animals. There is a long precancerous stage before cancer actually develops after excessive x-ray stimulation. According to Ewing, "Cumulative changes in cell nutrition and metabolism, handed down through successive generations, and transforming the normal into malignant

cells, and the loss of the antagonistic balance between connective tissue and epithelium due to hyperemia and loss of elastic tissue in the derma appear to be illustrated in this process."

Radium, too, has proved a very effective cause of cancer. The series of cases reported by Martland in which malignancy developed in those who painted dials of clocks and watches with radium is extremely interesting. The small camel's hair brush with which the solution of radium was applied was often placed on the lips to "point" the brush. The radium usually produced a necrosis about the jaw, but a large portion of the workers who survived developed a type of osteomyelitis and finally sarcoma. Deposits of radium were detected in the bone, particularly the femur, apparently having been carried to the medulla of the bone by phagocytic cells absorbing the radium from the stomach. It is probable that this effect is produced mainly by the particles from the alpha rays

The first experimental production of cancer by tar was effected by Yamagiwa and Ichikawa in 1914. No single application of an irritant is productive of cancer. It takes a long series of irritations, and it is this feature that is frequently overlooked. The painting of the ears of mice or rabbits with tar must be done at intervals over periods of months before cancer is produced One or two paintings are not effective. This seems to throw decided light upon clinical cancer, because it tends to demonstrate that a series of irritations, continued for a long period of time, is essential for the production of cancer.

Little believes that in cancer the balance between organ and tissue system is upset and that the waste materials are formed faster than they can be healthily absorbed. He remarks, "Cancer is a very natural situation and not in the ordinary sense of the word, a disease. It is a region of the body in which growth processes have gotten out of control and cannot be brought back again. It is a local insurgency, a rebel against the normally contrasted processes of destruction and repair which if balanced, are able to avoid a crisis.

"Because of the fact that cancer is due to upset balance between the organs and tissues of the organism, we find that its spontaneous occurrence is frequently correlated with a period or periods in the life of an individual when internal secretions and glandular activity in general are most likely to begin to wear out or to become unbalanced in relation to the other tissues of the body"

That there are many carcinogenic substances has been proved experimentally and by clinical observation The carcinogenic portion of tar that has been refined by Kennaway and Cooke has been producing rather regularly a malignant growth when injected into the tissues—carcinoma in epithelial tissue and sarcoma in connective tissue. J. W. Cook has made a substance from bile acid which after oxidation and dehydration and removal of the hydrogen and carbon dioxide, apparently reproducing artificially the changes that would go on in the human body, can cause cancer experimentally He has synthetically built up the same material.

The discovery of the production of cancer of the stomach in rats when infested by a small nematode worm, *Spiroptera neoplastica,* which inhabited cockroaches, was made by Jensen. Local irritations may come from various different sources A cancer has been produced in the mammary glands of mice by Bagg, by rapid breeding and withdrawing of the young at birth. In this way the mammary glands became

distended and doubtless irritated. It is probable that somewhat similar conditions in the human being may occur. The irritation or congestion of the mammary glands with or without actual lactation may overdistend the ducts and in the course of time produce sufficient irritation for the development of a neoplasm.

Experimental results which have been obtained by a number of investigators seem to show that there is some relationship between estrin, ovarian follicular hormones, and neoplasms of the breast. Estrin is a powerful stimulator hormone of the breast and uterus. Certain strains of rats and mice develop spontaneous mammary cancer in about 80 per cent of the females. Investigators have shown that if ovariectomy is done at an early stage in these mice the development of spontaneous cancer is diminished or practically abolished. Murray (1928) has shown that if male mice, which practically never develop cancer, are castrated and the ovary of a female mouse is transplanted subcutaneosuly, 7.1 per cent develop cancer in the mammary gland. It is an interesting fact that cancer of the breast occurs very frequently either in women who have not borne children or in those who have not nursed children. It would seem that the retained products of the mammary gland which are not drained normally through the ducts undergo some change which produces irritation. Thus Adair says, "Bagg, in our laboratory, began work on breeding experiments of mice. We know that our mice developed breast cancer in 5 per cent of our strain. He tied the nipple with a subcutaneous suture. The animals were bred, but could only suckle from the opposite side, so that the milk on the ligated side was locked in. The litter therefore nursed only half of the number of breasts. In this group the instances of carcinoma jumped from the normal 5 per cent up to 85 per cent. It is therefore obvious that research of animals is of vast importance especially when it can be hooked up with chemical studies and researches along *other* lines. We feel that there is a definite analogy between the nursing habits of mice from which we can eventually learn much of importance to the human race."

Little has produced cancer in the mammary gland in castrated male mice by implanting in them ovarian tissue which seems to stimulate an atypical growth in the undeveloped mammary gland of the male animal. It is doubtless true, too, that certain bacteria such as the *Bacillus tumifaciens,* which has been used by Blumenthal to inoculate rats, may cause cancer, probably not from any specific action of the bacteria, but from the irritation that they cause, as is produced by tar and other substances.

The mechanism of mutation, according to Ewing, may be responsible for cancerous change, and this may consist of three types: (a) a change in the gene; (b) translocation of a piece or pieces of one or more chromosomes; (c) abnormal distribution of one or more whole chromosomes. Such changes have been shown to arise in the course of chronic inflammation which often results in cancer.

The chicken or Rous sarcoma has been interesting in that a filtrable virus seems to have been responsible for the reproduction of this sarcoma in certain kinds of fowls. Murphy and his associates of the Rockefeller Institute have studied this carefully and believe that the agent responsible for these chicken sarcomas resembles very closely the substance that has been identified by Griffith and Dawson as capable of changing an undifferentiated pneumococcus cell into a specific strain. Murphy has suggested that these agents be called "mutagens."

Ewing remarks: "Out of this extensive field of research one seems justified in drawing the conclusion that there are many separate characteristic disease entities in the group now generally called cancer, and that observations made in one department may not be hastily transferred to another."

CLINICAL RESEARCH

In clinical research for cancer much has been done. Probably one of the most interesting results is the use of the Aschheim-Zondek test for the diagnosis of teratomas of the testicle or ovary. Zondek has demonstrated that in a case of chorioma of the testicle a secretion of the pituitary hormone, prolan A, is very marked. Russell Ferguson has elaborated this technic and by concentration of the urine can demonstrate early tumors of the testicle by using the principle of the Aschheim-Zondek test. This not only is very valuable for diagnosis but also serves to check up the radiation treatment. He finds that when the cells are practically destroyed, the rest is negative, but when the cells become active again, a positive test as in pregnancy occurs.

It has been the hope of the cancer research workers that some definite test for the early stages of malignancy will be found. From the nature of the disease, as has been outlined, and its protean aspects, both as to the clinical course and etiology, this does not seem probable, but to secure a reliable test even in one small group of tumors, such as neoplasms of the sex glands, is a high accomplishment The hope for the cure of all tumors lies in early diagnosis and prompt treatment. While several workers have developed tests for malignancy, to date none has proved to be of much clinical value because of the great error in specificity. Papanicolaou's method of staining free cells in body fluids and tissue scrapings is immensely valuable in the early recognition of cancer, but here, too, a follow-up tissue biopsy is usually necessary for a specific diagnosis

The various constitutional treatments for cancer have proved disappointing, and they have been too numerous even to mention. Those that have sprung from poorly thought-out or unscientific bases have been legion. A few have been worked out under scientific auspices. Thus, Blair Bell, Professor of Gynecology and Obstetrics in the University of Liverpool, noted that women who were working in factories where lead was used often aborted in the early stages of pregnancy. Upon examination of the products of the abortion, the fetus itself would usually be found intact, but there would be degeneration of the trophoblastic cells of the membranes. The resemblance in behavior of trophoblastic cells to cancer cells was striking They not only penetrate into the uterus itself, but before they are connected with the oxygen of the blood stream, their energy is derived from splitting glucose, which is similar to the method by which certain cancer cells seem to thrive. Blair Bell thought that the resemblance in behavior of trophoblastic cells and cancer cells was so striking and the effect of lead on trophoblastic cells was so marked that an intravenous injection of a so-called colloidal lead, really a suspension of small particles of lead, into the patient with cancer would be an effective treatment In a few cases there was benefit, and in some there appeared to be a cure. This aroused much enthusiasm, but the further result of this work was disappointing. The effect on the patient of this lead treatment when pushed is distressing; it produces a marked anemia, nausea and vomiting and very infrequently is any benefit derived It has been

rather generally abandoned. One of the premises, however, on which Blair Bell's treatment was based, that is, that cancer cells derive their energy chiefly from splitting glucose instead of by oxidation, has been partially disproved by the work of Warburg, who found that cancer cells require a definite amount of oxygen and, in fact, most tumor cells are very sensitive to a lack of oxygen. Some normal cells also show a high aerobic glycolysis. Some malignant cells apparently have low glycolysis and high respiration, so that a high glycolysis is not essential to the growth of all cancer cells.

Cancer of the stomach, which looms large in the mortality of cancer, doubtless comes, as does cancer elsewhere, from some preexisting pathologic condition or abnormality. Hurst believes that in cancer with achlorhydria, the achlorhydria results from chronic gastritis and not from the cancer, but that any cancer with free hydrochloric acid has its origin in peptic ulcer.

The study of cancer is full of interest from almost any viewpoint—chemical, biological, pathological, or clinical. It should not be insisted that all research work must have an obvious utilitarian or clinical value. Time after time research work which appeared to be of merely academic interest has been proved of the greatest practical value. The old story of the early development of electricity is well known When Michael Faraday and Joseph Henry invented the electromagnet and the dynamo it was considered merely a scientific toy. However, it should certainly detract none from the zest of any research to find that, in addition to its purely scientific interest, it may have some utilitarian or therapeutic bearing.

THE PRINCIPLES OF PROGNOSIS AND TREATMENT

There are only two methods of curing cancer that now receive approval from the highest authorities. One is surgical removal, either by a knife or by a cautery or electrosurgery, and the other is by radiation, either by x-ray or radium or radioactive substances *A combination of these methods is often beneficial.* The addition or subtraction of the different sex hormones and the use of nitrogen mustard gas and like substances have prolonged life and retarded the growth of malignant cells but have not cured any cases of authenticated cancer. A cancerous tumor consists of a number of cells, just as an army is made up of a number of soldiers. If they can all be extirpated at once, it is usually the best treatment, but sometimes because of the nature of the growth of the cancer or because of its infiltrating tendency and early dissemination, it is better to pick off the individual cells or soldiers as by radiation, than to attempt to remove them *en masse*. Laboratory research has done much in a therapeutic way not only in showing what type of tissue is radiosensitive and what is not, and so indicating the proper method of treatment to be employed, but also in providing a classification as regards the virulence of cancer. No one has done more in this respect than Broders, whose work is generally accepted.

The degree of differentiation of cancer cells is one of the surest indices to its malignancy. The lower grades of cancer are usually less susceptible to radiation, though this is not universally true, because basal cell cancer is very effectively treated by radiation. The higher grades with poor cytologic differentiation are usually more profoundly affected by radiation, though there are also some exceptions to this rule, such as melanotic carcinoma which is apparently but little affected by x-rays or by radium. However, it must be borne in mind that an extensive cancer

even of low grade is more dangerous than a high-grade cancer in the early stages. It is impossible, for instance, to give a favorable prognosis from the histologic structure of well-differentiated cells in a case of cancer of the bowel which has existed for years and infiltrated much of the surrounding tissue, while a high-grade malignancy found merely in one small portion of the tissue may afford a better outlook. Other things besides the histologic structure of the growth must be taken into consideration when making a prognosis. If, however, it has been determined by the microscope that the cancer is of a low grade of malignancy and is reasonably accessible, a removal by some surgical procedure, either by a knife dissection or by cautery, or by a combination of these, is advisable. Frequently both radiation and surgery can be applied effectively, as in some malignant growths of the neck and of the breast. Surgery alone seems best in malignancy of the gastrointestinal tract except in sarcoma. Radiation alone, as in the lymphosarcomas, is often indicated.

Each case of cancer must be studied by itself. The early stages of the disease are often elusive, but early diagnosis and prompt intelligent treatment will cure a large percentage of patients with cancer who now unnecessarily go down to an untimely end

These facts are not only interesting but have great practical importance in determining the prognosis and in deciding upon the treatment of malignant tumors.

METASTASES

The nature of metastases also has a distinct bearing upon the technic of operations upon cancer The cancer cell itself is the essential unit of the malignant growth, and transplantation of this cell is necessary in order to reproduce the growth. Some tissues afford favorable soil for the metastasis of certain malignant tumors.

It is well known, for instance, that cancer of the prostate tends to metastasize in bone. Cancers of the breast also frequently metastasize in the bone, though not so commonly as cancers of the prostate. Epithelial malignant growths, especially in the abdomen, have a marked tendency to metastasize in the liver, probably through the portal veins, though usually cancer cells travel by lymph channels Metastasis from cancer of the breast is practically always by the lymphatics, and though doubtless some cancer cells reach the blood vessels, they rarely survive in the blood stream except possibly in the portal circulation. Sarcomas, on the contrary, metastasize chiefly by the blood stream, and the common site of metastasis of sarcoma of the bone is in the lungs. *Cancers arising in organs that have a poor lymphatic supply* tend to remain stationary for a longer time than in organs where the lymph vessels are abundant. Thus, cancer of the colon and rectum, which have a relatively poor lymphatic supply, remains local much longer than cancer of the stomach, where the lymph vessels are abundant and metastases are early. Gastric cancer rarely metastasizes in the lungs but may follow the lymphatics to the neck Elderly people in whom the lymph supply is poor show a retarded metastasis, whereas in the young who are rich in lymph, metastases are more rapid Consequently, in elderly people, operation can usually be undertaken with more hope of cure than in the young

Some malignant tumors, as basal cell cancer, apparently do not metastasize at all. It seems probable that the cells of such tumors gain access to the lymph stream or to the blood, and are doubtless transported just as other cancer cells that

do metastasize. It is reasonable to suppose, however, that these transported cells find unfavorable soil at a distance from the growth, and consequently perish. This is interesting from a clinical standpoint, because resistance of tissues at a distance from this cancer appears to indicate, after removal of the cancer, transplantation of tissue from a distance, in order to inhibit the growth of any remaining cancer cells and to prevent recurrence.

TECHNICAL CONSIDERATIONS IN OPERATIONS FOR MALIGNANCY

There are certain general principles underlying the surgical treatment of malignant tumors which should in most instances be followed in any operation upon a malignant growth.

It is obvious that if a malignant tumor extends by cells being carried to tissues distant from the original growth and multiplying there, methods to promote this should be avoided. There should be no rough handling of the tumor during examination or during the operation. Drugless healers of certain cults who depend upon manipulation and massaging for a cure are capable of doing great damage in treating malignant tumors. Rubbing a lump in order to cause it to be absorbed particularly if it is a painless lump, is exceedingly dangerous. The fact that malignant growths in the early stages are usually free from pain unfortunately makes it possible for massage to be applied without protest from the patient—a treatment that would not be endured with an inflammatory mass. In a paper on the relationship of massage to metastasis in malignant tumors, Knox made a study of the effects of massage in cancer. A patient was observed on whom massage of the breast had been practiced before admission to the hospital. Metastases were scattered widely through the pectoral muscles, where metastases are usually very infrequently found. Experimentally Knox demonstrated that very gentle massage in certain transplanted cancers in mice, when the massage was done for a few minutes each day for a number of days, would set free particles of a tumor which would form emboli in the lungs and would produce numerous metastatic growths. The control experiments without massage showed a much smaller number of metastases.

If in metastasis cancer cells are transported by the lymphatics or by the blood stream, and are deposited elsewhere and grow, an incision into cancerous tissue through healthy structures immediately opens blood vessels and lymphatics to cancer cells and thus may hasten the extension of cancer by furnishing for the transplantation of the cells opportunities which without this incision would not have occurred If an incision into a tumor must be made through healthy tissue, the incision should at once be cauterized with either the electric cautery or pure carbolic acid. If the incision is exploratory and the growth is found to be cancer, a radical operation should be done at once. When a cancer is on the surface and is ulcerated, a piece of tissue from the margin of the ulcer can be taken without the added danger of opening lymphatics in healthy structures—but even here the wound should be cauterized and a radical operation should be done as soon as possible.

In cancers about the face and in cancers of the cervix uteri, tissue can be taken from the exposed ulcerated area with much less danger of spreading the disease than when the growth is deeper, as in the breast or neck.

Surgical operations for the cure of sarcoma are in principle somewhat different from operations for the cure of cancer. This is due to the difference in metastasis. Sarcomas, as a rule, metastasize by the blood stream, as has already been pointed out, and consequently a block dissection may be made without reference to the general lymphatic flow. An excision including a certain amount of healthy surrounding tissue with the tumor, and particularly if it can be made with the electric cautery, is satisfactory in many instances.

There are, of course, various degrees of malignancy in sarcoma of the bone, but it is somewhat more consistently virulent than many of the epithelial malignant tumors or cancer. The so-called giant cell sarcoma has been rather definitely proved by Bloodgood to be a nonmalignant tumor, and it is now called giant cell tumor instead of giant cell sarcoma.

In the osteogenic sarcoma it is doubtful whether radiation has any marked effect. The best treatment for an osteogenic sarcoma, whatever may be the subdivision, is resection or amputation. In occasional instances resection may be done, but this should not be a subperiosteal resection and should include the soft tissues near the periosteum. Instances in which resection is indicated are very rare, and it would be safer even then to amputate As sarcomas tend to metastasize in the lung, and particularly as osteogenic sarcomas are likely to have such metastases, a careful x-ray study should be made of the lungs before the amputation is done, for this may save a futile mutilation.

Usually a diagnosis can be made by the history of the case and by a careful roentgenologic study of the lesion. If this still leaves reasonable doubt, the patient should be operated upon with a tourniquet and an incision made down to the growth and a frozen section examined If the growth proves to be sarcoma, an amputation should be done without removing the tourniquet. Frozen sections, however, are not as dependable in lesions of the bone as in neoplasms of the soft tissues Not infrequently myositis ossificans simulates the structure of bone very closely. In such instances the study of the x-ray findings taken at different times and the histologic appearance should be correlated If there is still serious doubt, it would seem to be the part of wisdom to amputate rather than postpone the operation too long. While amputation in sarcoma of the bone is often followed by recurrence, in some instances there is apparently a permanent cure after an amputation for osteogenic sarcoma of considerable malignancy.

Ewing's sarcoma and myelomas are quite radiosensitive, differing from other sarcomas of the bone in this respect. It was thought at one time that they could probably be entirely cured by irradiation, but it is now known that while they will often regress rapidly after adequate deep x-ray therapy, recurrence is the rule; consequently, after x-ray treatment, amputation or excision should be done. Coley's toxins seem more effective in this type of sarcoma than in osteogenic sarcoma.

Operations upon tumors of the bone require the most careful study. The giant cell tumors are not malignant, although in exceptional cases they may apparently turn into malignancy. This is so rare, however, as to be a decided exception and there is full justification for treating this type of tumor conservatively. Irradiation in osteogenic sarcoma is of but little value. In the myelomatous type, deep irradiation is extremely helpful but should be followed by radical operation

Myxomas of the bone are really a type of sarcoma and should be treated as osteogenic sarcomas. In sarcomas of the breast and of the fascia a radical operation is often curative. In sarcomas of the fascia the electric cautery or the endotherm should be used wherever possible. In lymphosarcoma, or lymphoblastoma, operation is utterly useless, and this neoplasm is powerfully influenced by irradiation. Some cases of lymphosarcoma of the neck have been free from recurrence for years after irradiation alone.

Hodgkin's disease cannot be benefited by operation, but it can be affected by irradiation, though it does not seem to be quite so radiosensitive as lymphosarcoma. A combination of irradiation therapy and nitrogen mustard therapy or a similar substance seems to hold this condition in check, but complete cures have not yet been obtained.

Certain portions of the body, as the jaw, the kidney, the coccygeal region, the ovaries, and the testicles, are peculiarly liable to have tumors from embryonic remains or rests. Some of these tumors, as the so-called mixed cell sarcoma or embryoma, or Wilms' tumor of the kidney, are very virulent. This tumor of the kidney should be treated, first of all, by deep irradiation with x-ray, and after the tumor has regressed a nephrectomy should be done. Apparently there is no definite cure of these tumors by roentgen ray treatment alone; though the tumor may so diminish that it cannot be palpated, it practically invariably recurs and the recurrence seems to become radioresistant. After the recession has fully set in, a nephrectomy should always be done. In other tumors springing from embryonic remnants, as adamantinoma of the jaw, there is doubt as to the malignancy, and such tumors are usually radioresistant. A block dissection of this type of tumor, keeping rather close to the growth itself, would be the proper treatment.

In carcinoma of the mouth, lips, and tongue the proper therapeutic procedure depends upon several different factors. In carcinoma of the lower lip, not infrequently adequate irradiation by x-ray or radium effects a cure In carcinoma of the tongue or the buccal mucous membrane, the insertion of radon implants around the margin of the tumor and within the tumor itself often gives excellent results and is frequently curative. However, if the lesion is in the anterior portion of the tongue hemiglossectomy seems to give better results both as to survival and morbidity. When the bone itself is involved, the implantation of radon seeds in the soft tissue around the lesion, followed in a few weeks by resection of the bone, appears to be the most effective treatment.

When there is actual sarcoma of the jawbone, resection should be the treatment, though many cases that were formerly considered sarcomatous are now known to be either adamantinomas or other types of tumors with a mild degree of malignancy, where extensive resection will not accomplish any more than a limited close removal of the tumor. The implantation of emanations of radium can often be advantageously combined with the x-ray treatment in these lesions.

If resection of the tongue or jaw is essential and is to be extensive, it would be best to do a tracheotomy a few days before the resection and then block off the pharynx with moist gauze during the resection in order to prevent the aspiration of blood and mucus If the growth is well localized on the tongue and mucous membrane, frequently its excision with the endotherm knife and suturing of the wound

with silk are satisfactory treatment. The use of the endotherm is a great help in the modern surgical armamentarium and will often enable the surgeon to remove growths safely that could not be attempted with sharp dissection.

Healthy tissue should not be incised with a knife to reach possible malignancy in order to make a biopsy unless a radical operation follows immediately if the lesion is malignant, and even then the wound should be cauterized with carbolic acid. If it is necessary to traverse healthy tissue in a biopsy, an endotherm knife or electric cautery should be used. The method of obtaining sections from a trocar and cannula can be employed in some instances. However, in cases sufficiently serious to demand a biopsy, an incision with the endotherm would appear to be more satisfactory in obtaining a larger block of tissue.

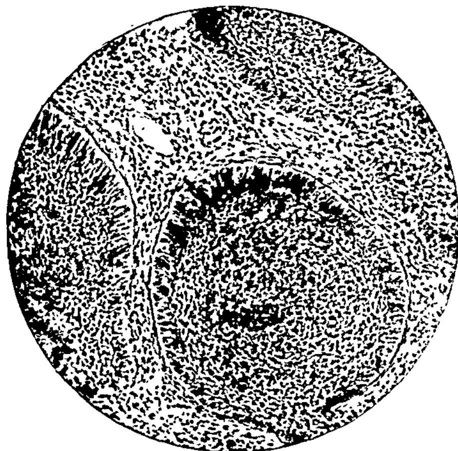


Fig. 11.—Photomicrograph of basal cell cancer from Mr C. P. B. There are large masses of epithelial cells surrounded by columnar-like basal epithelium. In certain areas this layer of columnar cells becomes very inconspicuous and actually disappears, though it is present in most of the slide. There are no "pearls" at any point. (×150)

Basal cell carcinoma of the face does not metastasize except in very rare instances (Finnerud). This seems to be due to the natural resistance in normal tissues to a basal cell type of cancer. This resistance must be overcome before the growth can extend. The histology of basal cell cancer is varied probably because of its close relationship to the undersurface of the epidermis from which sebaceous glands, sweat glands, and hair follicles also arise (Figs. 11 and 12). The spinous cell squamous cancer, however, often readily metastasizes at distant points, as in the lymph nodes of the neck Advantage may be taken of this peculiarity of the basal cell cancer in remaining local. After first excising the cancer, the raw surface of a

pedicle flap made at some distance from the margin of the cancer is transplanted to the raw surface left by excision of the cancer. This flap should be outlined at the time of operation and transplanted a few days later. In this way there is carried to the surface from which the basal cell cancer was excised, tissue from a distance whose natural immunity has not been broken down by the growth of the cancer. In small basal cell cancers about the face, simple excision with the cautery or the application of radium or roentgen ray is usually sufficient for a cure, but in the persistent type where there is recurrence in spite of such treatment and the growth becomes extensive, involving the bone or mucosa, the application of a pedicle flap taken at some distance from the cancerous growth is apparently of very considerable value. (Figs. 15, 16, 17, 18, 19, and 20.)



Fig 12.—Photomicrograph of an extensive basal cell cancer which involved the antrum, upper lip, and a portion of the alveolar process and hard palate This area is from the mucous membrane The basal cells penetrated not more than 1 cm. from the edge of the ulcerated area There is a tendency toward adenomatous-like arrangement in certain areas This is the adenocystic type of basal cell carcinoma. (×155.)

When a cancer is of the squamous cell type, different methods must be pursued (Figs. 13 and 14). Transplantation of flaps in such a cancer has *no effect in* retarding the growth or in preventing recurrence. The recurrent cancer of the squamous cell type readily grows into a flap.

It is important to differentiate the different types of squamous cell cancer. Broders has done very valuable work in calling attention to the difference in malignancy of squamous cell cancer. He has noted four grades, and of course the classification into grades may be more extensive In Grade 1, there are many "pearls"

and advanced differentiation of the cells which approach maturity (Fig. 14). This is a mild type, and very rarely metastasizes into the lymph nodes. It grows slowly, and local excision is usually all that is necessary for a cure (Figs. 13 and 14). If a squamous cell cancer is of this type, a mutilating and extensive operation is not necessary. At the other extreme of the classification, Grade 4, there are no "pearls," and the cells are but slightly differentiated. This type is exceedingly malignant, and requires the most radical operation combined with treatment by roentgen ray and radium. Between these two extremes are the other grades of malignancy, which Broders classifies as 2 and 3, and not infrequently fractional numbers may be used to indicate a grade between the integers. This classification is of the greatest practical value to the surgeon, both as to treatment and prognosis, and should be determined before operation is completed



Fig. 13.—Photograph of patient, A. T., aged sixty-two years, who gave a history of having had a lesion on the lower lip for ten years The growth was quite extensive. There was one apparent metastasis in the left submaxillary region. Biopsy showed a low-grade carcinoma, not more than Grade 1, which is shown in Fig 14. The local growth was excised, the lip reconstructed, and a block dissection was made in the left submaxillary space. The patient remained well as long as he was traced, about seven years after the operation. If a more malignant type had been shown in the biopsy, such an operation would have been unjustifiable, but with the grading it resulted in cure (*From Horsley, J. S : South. M. J. 19: 292, 1926.*)

In cancer about the face with metastasis in the neck it is usually not practical to make a block dissection from the original focus in the face to the metastasis. The face, tongue, and neck are richly supplied with lymphatics The lymph nodes are grouped in certain definite areas. Apparently the cancer cells are quickly transported through these active lymph channels as emboli and rarely form growths in the channels themselves. Unless the primary lesion is so situated as to make it practical to do a block dissection from the growth into the neck, it is reasonably

safe to excise the primary growth on the face or tongue, preferably with the endotherm, and to do the operation on the neck as a separate procedure.

The electric cautery and the endotherm knife are the greatest help in operations upon almost any malignant tumor. *In block dissections, if the cancerous* tissue is opened, it should at once be cauterized with the electric cautery or the endotherm. The wound should be flushed out at intervals with salt solution to wash away any cancer cells that may have been spilled. Theoretically it would be safer to do the whole dissection with the electric cautery or the endotherm. As a matter of fact, however, the cautery or the endotherm, if used about the large vessels, necessarily would be dangerous because of the possibility of secondary hemorrhage. It seems safer to do a block dissection of the neck with a sharp knife and

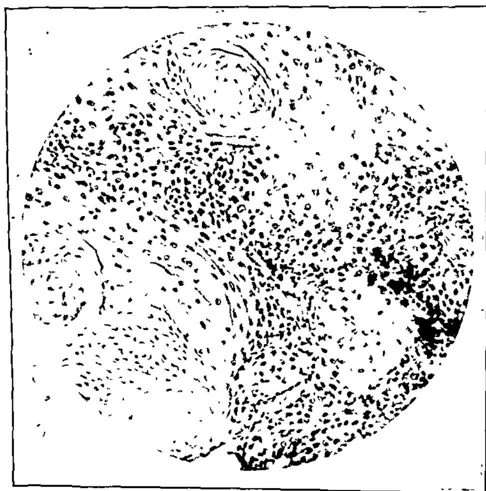


Fig 14—*Photomicrograph of specimen removed from A. T.* (Fig 13), showing mature cells, numerous "pearls," and squamous cell cancer about Grade 1. (×140.) (From Horsley, J. S.: South M. J. 19: 292, 1926)

to use the electric cautery or endotherm at suspicious points (Fig. 21). If the cancer is very extensive, radium emanations or needles may be inserted at strategic points, particularly at the base of the neck or where the cancerous tissue seems rather near the margins of the dissection.

In block dissection for cancer of the neck or breast, drainage should always be used, preferably through a stab wound. The desirability of this has been emphasized in the chapter on drainage. Malignant cells that are left behind may be absorbed into the open lymphatics, but if drainage is instituted, the cells which

float in the lymph serum poured out into the wound may be drained externally, and the drain itself promotes a reversal of the lymph flow so that cells already in the lymph channels may be washed toward the drainage tube.

In cancer of the breast the principle of block dissection introduced by Halsted and independently by Willy Meyer has been fully adopted. The principle is to remove the breast and surrounding tissue in one mass. Handley has shown that cancer cells of the breast not only are carried by the main lymph trunks to the axilla and probably through the lymph vessels to the fascia and tissue over the recti muscles and to the abdomen, but according to him they spread in lymph channels in columns radiating from the original focus into the subcutaneous tissue.

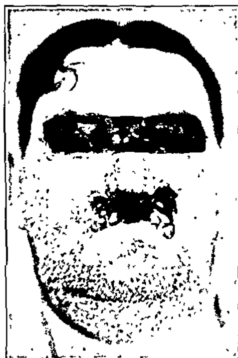


Fig. 15.



Fig. 16.

Fig. 15—Basal cell cancer before operation. Mr. G K P.

Fig 16—Condition of the mouth sixteen days after operation. The slough has not yet fully separated. (See Fig. 15.) The flap in the neck has been outlined but does not show here.

Many of these cells near the original tumor die and the lymph channels in which they lodge disappear. Consequently, it is not necessary to make an exceedingly wide skin incision for excision of cancer of the breast, which in the early development of this operation appeared to be essential The amount of excised skin should be generous, but it is very important to make a wide undermining dissection, including in the mass to be removed the subcutaneous fat and fascia, in which tissue Handley has shown the cancer cells grow in a radiating manner

In cancer of the stomach and intestines, the principle of block dissection should always be followed. *Dissection of the mesentery and the attachments of the stomach or the bowel begins at the farthest margin along the proposed line of division.* The stomach or intestine should never be opened until all of the mesenteric and other attachments have been separated, the vessels tied, and the surrounding tissues packed off with gauze. If a lymph node or a metastatic area has been

accidentally incised, it should be cauterized at once. The difference in the virulence of cancer of the large bowel and cancer of the stomach may be at least partly attributed to the greater lymph supply of the stomach.

Teratomas of the testicle and ovary, though they may show fairly well-differentiated cells in some areas, are very sensitive to irradiation. A teratoma, or embryonal carcinoma, of the testicle, even if small, should first be submitted to irradiation, preferably by roentgen ray, and then the testicle should be removed.



Fig 17.—About a month later. The slough has separated, and the wound has partially healed. The flap in the neck has been gradually dissected free, and its undersurface is partly covered with Thiersch grafts. It is ready to be denuded and transplanted to the region of the upper lip, according to the method described in the text. (See Fig 16.) Several years later the patient was apparently cured

It would seem, however, that the extensive operations that have been devised for this tumor of the testicle, including not only removal of the testicle and cord but resection of the retroperitoneal space, are unnecessary and unjustifiable, because modern deep x-ray therapy, accompanied in certain instances by the application of radon implants if necessary, offers a far more favorable prognosis as to cure than even the extensive block dissection and is at the same time less dangerous. If the growth is at all extensive, operation of any kind would probably be unwise, but in the early stages local excision after irradiation, and followed by irradiation, will doubtless give the best results.

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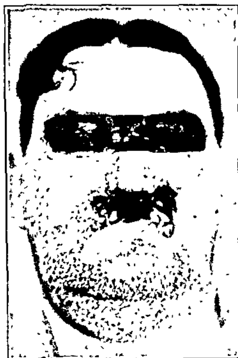


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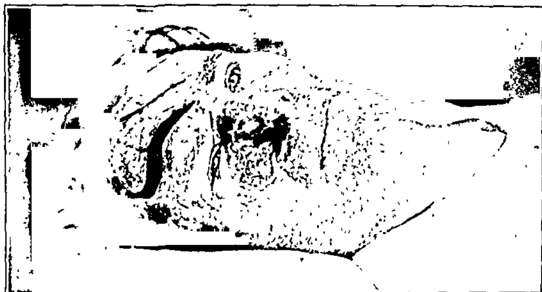


Fig. 18.—This patient, Mr. C. B., had a recurrent basal cell carcinoma of the right cheek and adjoining portion of the nose that had been treated by roentgen ray and radium and by operations. The photograph shows the growth excised with the electric cautery and the outline of the flap from the forehead which is to cover the raw surface from which the cancer was excised.



Fig 19



Fig 20

Fig 19 —Mr C B The flap has been sutured in place, and a soft clamp is applied to the flap a short time each day in order to encourage the blood supply from the region of the excised cancer to the flap

Fig 20 —Photograph of the completed operation.

Operations for malignant tumors occupy a considerable portion of the general surgeon's work. It seems essential for him to study the type of malignancy for which an operation is undertaken, and to understand as far as possible the nature of the growth as well as the resistance of the patient who is the host of the tumor.



Fig. 21.—Drawing showing block dissection of a well-advanced carcinoma which involves adjoining structure The tissue was re- ternomastoid muscle, and the surrounding The view is from within.

ROENTGEN RAY AND RADIUM BURNS

It may be of interest to consider briefly the surgical treatment of radiologic burns in which there is no malignancy. When they occur they often follow the use

of the roentgen ray or radium in the treatment of cancer. They are very painful and are difficult to cure by the usual methods.

These burns require a different principle of treatment from what is necessary in an ordinary ulcer. This is because the rays from radium or the roentgen ray have a very pronounced stimulating effect upon the endothelial cells of the intima of blood vessels. When radium or roentgen rays destroy normal tissue, the effect of the rays that penetrate through tissue that still lives causes such a marked proliferation of the endothelium of the blood vessels that the lumen of the vessels is greatly diminished or the vessels may even be converted into cords (Fig. 22). For



Fig 22.—Photomicrograph of tissue from a radium burn. The vessel has been entirely occluded by the proliferation of endothelial cells. The muscular coats of the walls of the vessels are shown. In other areas not shown here, small new vessels are seen that are normal. (×100.)

this reason the lesion continues as an ulcer and is exceedingly slow to heal. The local tissues are ischemic, and this not only prevents repair of the tissues but causes ischemic pain in the nerves. If Thiersch grafts or free whole skin grafts, are transplanted to such a burn, they do not live because the nutrition of the surrounding parts is greatly diminished by the partial or complete obliteration of the lumen of the blood vessels and not enough blood can be transported to support the tissue already there, much less bear the additional nutritive burden of sustaining the grafts. It is, then, essential in the treatment of these lesions that are at all extensive to provide not only an epithelial covering but a new blood supply that will support the covering and at the same time carry blood to the poorly nourished tissue involved in the burn. The graft, therefore, should always be a flap with a pedicle and the blood supply that comes through the pedicle should be developed by gradually dissecting the flap free as described in the section on Plastic Surgery. In this way not only will the epithelial covering have its proper nutrition, but the poorly nourished tissue beneath will also have an additional blood supply.

This principle may be used in repairing defects caused by radium elsewhere. A large fistula in the bladder following applications of radium to the cervix uteri

cannot be repaired by the ordinary technic for closing a vesicovaginal fistula but demands transplantation of flaps of mucosa or other tissue that will be permanently furnished by nourishment through a pedicle.

When the tissue affected by irradiation can be fully removed down to a good blood supply, free grafts may be applied.

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CHAPTER 5

INFECTION; SHOCK; HEMORRHAGE; BLOOD TRANSFUSION; FLUID ELECTROLYTE BALANCE

EVERETT I. EVANS

The introduction of potent antibiotics for the prevention and treatment of surgical infections has greatly lessened the hazards of "operating room contamination," but success in surgery still depends largely on strict adherence to the principles of asepsis and wound care laid down by Lister in 1879.

PREPARATION OF THE OPERATIVE SITE

The preparation of the patient's skin for operation is not done in the most efficient manner in many clinics. Surgeons often place unwarranted faith in germicides and antibiotics and are not aware that preparation of the patient's skin should follow the rules of ordinary body cleanliness. Soap and water remain the best agents for cleansing the skin and for the removal of bacteria.

The surgical committee, in close cooperation with the nursing service, should have clearly defined technics for preparing the skin for the common surgical operations.

Facilities and personnel should be available in well-ordered hospitals for preparation of the operative site at least twelve hours before operation. The area should be cleansed with soap and water before it is shaved Shaving is best done by a sharp, straight razor, but nowadays few persons are trained in the use of straight razors. Shaving is done safely with one of the ordinary "safety razors," care being taken not to scratch or cut the skin with the corners of the blade. When all hair has been removed, the skin is washed with warm tap water and thoroughly dried. Alcohol dressings are not recommended The area may be covered by a sterile towel.

The operative site is again prepared just before the sterile drapes are applied It is important that the patient be placed in proper position before this is done.

The skin may again be washed with liberal amounts of soap and water, especial care being devoted to cleansing such areas as under the breasts, the axillae, the umbilicus, and the groins. Following the use of soap and water, the skin is dried, cleansed with ether, and then thoroughly painted with one of the commonly used germicidal solutions A number of effective germicides are available, but before using any of them, the patient should be questioned carefully as to sensitivity to iodine, organic mercurials, etc

One of the best germicides is a U.S.P. solution of iodine, which should be applied to the skin, allowed to dry for a minute or so, then removed by swabs soaked in 70 per cent alcohol Unless iodine is carefully removed by alcohol, it

may cause disagreeable, even serious, burns. For this reason iodine has been supplanted in many hospitals by the organic mercurials such as Mercresin, Merthiolate, Metaphen, etc. These solutions are left to dry on the skin. Great care should be taken in applying any germicide about the genitalia or perineum, and especially about the eyes.

Aqueous Zephiran and, more recently, synthetic detergents containing G-11 have been introduced as safe and effective bactericidal agents. They are excellent for preoperative preparation of the vagina and perineum when combined with efficient mechanical cleansing with abundant quantities of water.

Fresh traumatic wounds are best prepared for repair by soap and water or by detergents containing G-11.

PREPARATION OF THE SURGEON'S HANDS

Surgeons should exercise the greatest care in avoiding gross contamination of the hands with pathogenic bacteria. When dressing infected wounds, the surgeon should wear gloves and use instruments, changing gloves after each dressing and washing his hands thoroughly when he has finished.

The surgeon should form the habit of washing his hands frequently with soap and water and must use especial care to keep his nails clean. He should also avoid conditions which cause drying and cracking of the skin of the hands.

Mechanical scrubbing with a suitable brush and soap and water probably still is the most effective method for removing bacteria from the skin. A fairly stiff brush is required, but it must not be so stiff as to injure the skin. Orderly and vigorous scrubbing for from seven to ten minutes is required. At the end of the scrub, the soap is rinsed away with tap water and the hands and arms are dried with a sterile towel. If ordinary soap has been used, the arms and hands are immersed in 70 per cent alcohol, then 95 per cent alcohol. Since the 95 per cent alcohol is rapidly removed by evaporation, the sterile gown may be put on without using a towel for drying the hands and arms, a distinct advantage when there are untrained individuals on the surgical team.

Synthetic detergents containing G-11 are now widely used for cleansing the surgeon's hands and arms. In many hospitals these agents have replaced soap and water and alcohol. Three minutes' scrubbing with the G-11 detergents was said to be sufficient, but Price apparently has shown this to be inadequate. No alcohol is used after the detergents, so that a fine film of this bactericidal agent is left on the skin, with the idea of destroying bacteria which reach the skin surface from the depths of sweat glands and hair follicles.

Between so-called "clean cases," a three-minute scrub with a G-11 soap is generally considered adequate.

SURGICAL INFECTIONS

Space does not allow a full discussion of all the aspects of treatment of postoperative infections, but certain principles are presented. Penicillin and the other antibiotics have brought about a revolution in the prevention and treatment of postoperative infections, but the use of these substances has not altered appreciably the necessity for drainage when pus is discovered. Too much reliance may be placed on the antibiotics rather than on good wound care.

Antibiotics frequently are administered in the treatment of surgical infections, *without efforts being made to discover the responsible organism and to determine* the sensitivity of the causative organism to the various antibiotics.

"If we are to give the patient the full benefit of antibiotic therapy, it is necessary to discover the causative organism and to determine its sensitivity to the available antibiotics. This requires close cooperation with a bacteriology laboratory.

"Suspicious exudates should be collected with proper precautions and sent at once to the laboratory for appropriate examination. A preliminary report on the causative organism and its sensitivity to the antibiotics usually can be given in approximately 24 hours. Mixed infections require somewhat longer.

"In acute infections treatment should be instituted at once, using the antibiotic which seems most likely to succeed Should the laboratory studies indicate that another antibiotic or a combination of antibiotics will be more effective, the treatment should be modified, as indicated." (Meleney.)

The routine use of antibiotics in clean surgery is to be avoided. The indiscriminate use of antibiotics, especially penicillin, has led some operators to believe they can disregard established surgical principles. Nothing is further from the truth.

With penicillin, streptomycin, Chloromycetin, terramycin, bacitracin, neomycin, polymyxin, and other antibiotics available for the control of infection, one should choose the antibiotic for use in the individual case with deliberation and care commensurate with his experience and knowledge of infections

Little advance has been made in the sterilization of the air in operating rooms. Ultraviolet irradiation, successfully employed by Deryl Hart, has not been widely adopted, probably because of the discomfort imposed upon the operating room personnel by the required equipment. The circulation of air cleared of bacteria-laden dust particles by the use of the "Precipitron," or by filtration, as advised by Colebrook and Bourdillion, has better prospects of being generally adopted Both of these methods are still relatively elaborate and expensive, but no doubt will become simpler and more reasonable in cost

The value of these methods of eliminating bacteria from the air in operating rooms apparently is not appreciated by those surgeons who depend upon the antibiotics to prevent and control wound infections

SHOCK AND HEMORRHAGE

In 1940 the relation of shock to hemorrhage was so little understood that they often were discussed separately The extensive experimental and clinical investigations on wound shock during World War II have greatly clarified this relationship. The value of blood pressure readings in estimating the severity of shock has been stressed.

It is now clear that the chief cause of traumatic shock is loss of whole blood in the zone of injury, and the chief cause of surgical shock is the loss of whole blood from the site of operation. It seems well established that blood loss must be of the magnitude of 25 to 40 per cent of the total blood volume to produce severe shock in the healthy, unanesthetized, young adult However, individuals suffering from malnutrition, liver disease, severe infection, dehydration, or old age are more susceptible to blood loss That certain anesthetic agents increase the severity of shock is now generally appreciated Since the cause of surgical shock is severe blood loss, the best treatment for surgical shock is prompt restoration of that which has been

lost, i e., whole blood. Although this would seem to be obvious, some surgeons still rely on saline infusions rather than whole blood for shock therapy during operations. Salt solution is better than nothing, *but not much better.*

The best treatment for surgical shock is prevention. This implies the prevention of blood loss by careful hemostasis during operation and the prompt replacement of blood which is unavoidably lost. The first principle, the conservation of blood, is equally as important as the second, but in these days of blood banks, this is too often forgotten.

Before the start of any major operation in which massive blood loss may occur, an accessible vein is cannulated and a slow infusion of 5 per cent dextrose in water is started. Prior to operation the patient's blood is carefully typed and cross-matched with one or more suitable donors or with "bank blood." Blood is given by the indirect or citrate method as blood loss occurs, not after the patient has gone into shock on the operating table or upon return to his bed. If no appreciable blood loss occurs, blood usually should not be given.

Plasma, albumin, and certain plasma substitutes are effective agents in the immediate treatment of surgical shock, if not required in too large quantities (usually above 1,000 c.c.), but they shoud not be considered "blood substitutes"; they contain no red blood cells. *There is no substitute for whole blood* in the treatment of surgical shock.

Intravenous infusion of whole blood is effective in most cases of surgical shock if blood replacement is adequate in amount and rapid, but when this method fails, intra-arterial blood transfusion may prove lifesaving. The bone marrow route may be employed for transfusion in infants and in persons with no accessible suitable veins, but the surgeon rarely will need to use this route if he has learned "to find a vein" in debilitated persons or in those in shock The femoral vein always can be found and entered, even in patients in deep shock.

Shock occurs in combined water and electrolyte loss, such as occurs with persistent vomiting, from pyloric or intestinal obstruction. Although a deficit in plasma volume in these patients commonly is observed, their chief need is the restoration of body fluids by the administration of electrolytes and water. This is accomplished by the intravenous infusions of fairly large quantities of 0.9 per cent sodium chloride solution, usually with some potassium chloride added, or if there is a predominant salt loss, with infusions of 2 per cent sodium chloride solution Shock in infants suffering from severe diarrhea often is best relieved by infusions of sodium lactate solution Shock accompanying gastric dilatation following operation generally is not relieved until the stomach is deflated by lavage.

Shock may accompany severe postoperative infection, especially when the peritoneum is diffusely involved. If the picture of shock develops in a patient who recently has had an intestinal resection, one should suspect leakage at the suture line. Shock also may accompany gangrene of the bowel wall, as in volvulus. Although whole blood transfusions are of benefit in these conditions, surgery usually is the only satisfactory definitive treatment.

Concealed, continuing blood loss is commonly the cause of shock which appears early in the postoperative period. If after a major operation, the patient goes into shock four or five hours later, he should be given 500 to 1,000 c.c. whole blood. If the patient's condition does not improve or if the improvement is transient, and the blood volume has not been restored to an effective level, more than likely the

patient continues to bleed, in which event immediate operation is necessary. After thoracic operations, however, shock may be due to interference with respiratory exchange, so when shock persists despite adequate blood replacement, the chest must be carefully reexamined, including x-ray studies. This is especially important in those patients who may have developed a pneumothorax in the course of surgery in the region of the diaphragm. It is surprising how often the pleura is torn during the simple procedure of removing a portion of the twelfth rib.

THE SEQUELAE OF PROLONGED SEVERE SHOCK

Irreversible Shock

Although not of infrequent occurrence, the mechanism of irreversible shock still is incompletely understood. When the shock state is allowed to persist for more than two to four hours, many patients cannot be resuscitated, even by multiple blood transfusions. There is at present no effective treatment for irreversible shock. The lesson is simple: the surgeon must recognize shock early and treat it adequately.

Cardiac and Central Nervous System Damage

The heart and brain are affected adversely by prolonged shock more often than is commonly recognized. Indeed, Wiggers considers myocardial damage during the shock state to be one of the principal causes of irreversible shock.

Renal Damage

The exact mechanism of production of renal insufficiency following prolonged shock is not clear. Often these patients have been in shock for some time and have received a number of whole-blood transfusions. Which is more important—reduced blood flow through the kidneys, or intravascular hemolysis, the result of the blood transfusions—is not known. The patient who shows oliguria or anuria, hypertension and azotomia, postoperatively, must be studied carefully in an attempt to discover the cause of the renal insufficiency. It is important that the surgeon realize that the "shock kidney" does not respond to the forcing of fluids. The treatment primarily is supportive until the lining cells of the renal tubules have had time to recover or regenerate The conservative treatment advised by Muirhead and Hill is the one most readily applicable in those hospitals not possessing an "artificial kidney" Peritoneal lavage, advocated cautiously by Fine, is rarely justifiable since it so often is followed by severe peritonitis.

BLOOD TRANSFUSION IN SURGERY

Blood transfusion, though invaluable and usually considered a simple undertaking, is in fact a complicated procedure. The prevention of reactions has been largely delegated to the hospital laboratory. The knowledge required for the prevention and control of blood transfusion reactions is so highly technical that few surgeons are prepared to accept the responsibility For this reason the more complex problems connected with blood transfusion reactions are not discussed in this chapter. However, the surgeon who orders a blood transfusion for his patient should realize there are many dangers associated with this procedure. Adverse reactions can occur even though careful laboratory control has been employed. Far more serious is the procedure when such control is lacking! The danger accom-

panying blood transfusion is so great that the surgeon must demand adequate and efficient laboratory control of transfusion procedures. Such determinations as blood grouping, blood typing, RH factor, and crossmatching are essential and must be carried out by skilled technicians, who should be under the supervision of a physician, competent in this field of medicine. Close cooperation between the clinician and the laboratory is necessary. The laboratory should be advised of the nature and severity of every transfusion reaction. This enables the laboratory staff to search for the cause of each complication, such as chills and fever, urticaria, hemolysis, renal insufficiency, and finally the transmission of diseases such as syphilis, malaria, and, more particularly, infectious hepatitis.

One of the most troublesome results of the administration of multiple blood transfusions (citrate method), given rapidly for severe hemorrhage, is the development of a purpuric tendency. Bleeding continues despite all efforts to staunch the flow; blood seems to flow from every injured capillary. This complication has been attributed to the excess of sodium citrate by some, while others point to a deficiency in certain clotting factors in stored blood. In our limited experience, giving more citrated blood makes a bad matter worse. Bleeding of this nature may cease after the infusion of fresh, whole blood, given by the multiple syringe technic of Lindemann. Some writers advocate using 50 c c. glass syringes for this purpose, but our experience indicates that 20 c.c. glass syringes are much easier to handle. Every hospital should have on its staff several individuals proficient in the multiple syringe method of blood transfusion because in certain circumstances it can be lifesaving.

The Multiple Syringe Method of Direct Transfusion

It is necessary to have three operators. They should be trained to thorough teamwork as it is essential to complete the transfer of blood as rapidly as possible. Every second of delay from drawing the blood from the vein of the donor to inserting it into the vein of the patient hinders that much the success of the procedure. Not only that, but any undue delay in cleaning the syringes may cause the needle in either the donor or the recipient to become occluded, and when clotting in the needle once begins, the transfusion is materially affected.

The transfusion can be done in the patient's room, though it is often more convenient in the operating room where there is a good light. If the patient is desperately ill, the transfusion can be satisfactorily arranged at the bedside.

Two large basins of the type used for washing the hands of the surgeon during an operation and one small basin are necessary. One of the large basins is empty and serves as a receptacle for the discarded contents of the syringes. The other is filled with sterile distilled water and the small basin is filled with normal saline solution. Two medicine glasses, each of 30 c.c. capacity, are also provided, one being filled with 10 per cent solution of sodium citrate and the other with 15 c.c. of 0.5 per cent procaine solution to which 2 drops of Adrenalin solution are added. There should be at least five or more 20 c.c. syringes for obtaining the blood and two 10 c.c. syringes for saline and procaine solutions, together with two hypodermic needles for injecting the anesthetic and the needles necessary for withdrawing and administering blood. The needles to puncture the vein are No. 15 or No. 16 gauge Unger transfusion needles. There should be at least three of these needles. The syringes are probably best sterilized by soaking for one hour in 70 per cent alcohol.

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Operator No. 1 draws the blood from the donor. Operator No. 2 cleans the syringes, and Operator No. 3 injects the blood into the vein of the patient. The *patient and donor should* be *lying* down and within easy reach of the central table where Operator No. 2 is stationed with basin, syringes, etc. A superficial vein in front of the elbow of both patient and donor is selected. The skin immediately over the prominent vein is cleansed in the usual way and infiltrated with procaine solution, using a small *needle. The procedure in entering the vein of the donor* and of the patient is similar. A tourniquet of a soft rubber tube is applied to the middle of the upper arm sufficiently tight to retard the venous flow without occluding the artery. After the tourniquet has been on several minutes and the veins have become distended, the needle with its sharp hollow obturator is introduced obliquely through the infiltrated skin into the vein with the bevel of the point downward. After entering the vein, which is easily determined by a few drops of blood coming through the obturator, the obturator is removed and the needle is gently passed about 1 cm. upward in the vein and is held in this position with the left hand. Some operators find it more convenient to have the needle in the donor inserted downward toward the hand, thinking they thus get a better flow of blood. The needle for the patient is always pointed upward Immediately after removing the obturator, the syringe is attached to the needle and the transfusion may be *begun. Up to this point the procedure is identical in both the donor and the* patient. After the vein has been entered in the patient, the patient's tourniquet is released and a small amount of saline solution is injected to ascertain whether the needle has been properly placed and that there will be no leakage about the vein. When the needle and syringe are attached or detached, the needle is held between the index and middle fingers of the left hand of the operator, and while the syringes are being changed, the thumb is placed over the end of the needle as a plug to prevent the loss of blood Operator No 1 draws the syringe full of blood as quickly as possible, disconnects the syringe, places the thumb of the left hand over the base of the needle, and lays the syringe *filled* with blood on the table within easy reach of Operator No. 3, who picks up the syringe, connects it with the needle that is in the vein of the patient, and quickly empties the syringe into the vein. He then detaches the empty syringe, places his thumb on the base of the needle, and passes the syringe to Operator No 2, who carefully discharges any blood left in the syringe into the empty basin and washes it out several times with the sterile distilled water, each time emptying the syringe into the empty basin so that the distilled water is not contaminated with blood Then a small amount of the sodium citrate solution is drawn into the syringe and expelled into the empty basin. This syringe is placed within easy reach of Operator No. 1, who connects it with the needle in the donor's vein and then repeats the operation. If there is any delay, normal saline solution should be slowly injected into the needle until the transfusion is resumed This may be done both in the donor and the patient If it is necessary to inject saline solution into the donor, the tourniquet on his arm should be temporarily removed. This is to prevent the blood from clotting and obstructing the needles

Five hundred cubic centimeters of blood is the usual amount given in a transfusion. While the transfusion is going on, the pulse of both donor and recipient should be taken at intervals of a few minutes After the transfusion has been com-

pleted, the needles are quickly withdrawn, and a small gauze sponge held firmly in place with a strip of adhesive plaster is applied over the site of the puncture in the vein. This gauze sponge should be applied very tightly to prevent any leakage about the vein which would cause a hematoma.

Occasionally it is difficult to find a satisfactory vein in the patient. In such instances the vein must be exposed by an incision and the needle introduced into the vein, or the vein is opened and an intravenous cannula is inserted and tied in place with a ligature (Fig. 23). The intravenous cannulas used have the regular Luer base, and after insertion the same procedure is carried out as when the Unger transfusion needle is used.

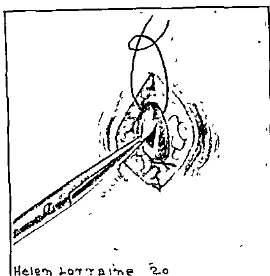


Fig 23.—A ligature has been tied on the distal side of the vein, another ligature placed but not tied on the proximal side, and the vein has been opened with an oblique incision

FLUID AND SALT REQUIREMENTS IN SURGERY

In ordinary practice the surgeon concerned with problems of fluid and electrolyte requirements is chiefly interested in water, the cations sodium and potassium and the chloride anion Water makes up about 70 per cent of the total body weight. About 80 per cent of the water of the body is found in the cells, the rest in the extracellular fluids, that is, in the interstitial space and in the blood vessels (Fig. 24). The capillaries are somewhat permeable to water and electrolytes The cell membrane freely allows passage of water, less so of electrolytes It is now well known that the sodium and potassium ions readily pass across this membrane.

The osmotic pressure of the body fluids, intra- and extracellular, is maintained by water and electrolyte shifts across these membranes. In Fig 24 is shown the composition of body fluid components in the normal man It is seen that the chief cation of the extracellular fluid is sodium and that of the intracellular fluid, potassium. The bulk of the chloride anion is in the extracellular fluid, but recent studies have demonstrated some chloride in the cell. Under normal conditions there is probably not too great transfer of sodium and potassium in and out of the cell, from one body space to another, but in salt depletion sodium can replace, to some extent, potassium loss from the cell

The shifting extracellular electrolyte, in the normal state, is predominantly sodium chloride. Under ordinary conditions the kidneys adjust excretion of water

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crease in either water or salt output (or both) by the kidneys. When renal mechanisms are normal, one may expect to find small urine volumes with water depletion, and low urine salt concentration and excretion with salt depletion. Dehydration is a term that covers both conditions, named according to the initiating causes, primary water depletion and primary salt depletion.

In patients unable to eat or drink, dehydration often is made much worse by the added loss of body water through the skin and respiration (insensible water loss). This extra loss may amount to 700 to 1,000 c.c. of water daily and can be as high as 3 to 5 liters daily if the environmental temperature is much above 100° F.

In primary water depletion the extracellular fluid tends to become hypertonic, although this tendency is compensated for by two mechanisms: water moves from the cell into the extracellular space, and the kidneys diminish their water output to the minimum obtainable by tubular reabsorption. Even though intracellular dehydration is marked, there may be no great change in either the plasma volume or electrolyte concentration. In this condition one may find a small urine volume and normal or increased concentration of plasma, protein, and electrolytes. A marked decrease in water excretion in primary water depletion can occur with very little change in plasma concentration.

Primary water loss is best replaced by the administration of water and no salt, as 5 to 10 per cent dextrose in water. If sweating is responsible for a major portion of the water loss, replacement of salt should be by hypotonic salt solution. A suitable hypotonic salt solution is obtained by combining 0.9 per cent sodium chloride solution and 5 per cent dextrose in water. The urine output is a fairly good guide to the amount of water required and a daily urine output of 800 to 1,000 c.c. is adequate for patients with normal kidney function. Patients with diminished renal concentration power may have to be given much larger amounts of fluid to correct primary water depletion and may have to excrete as much as 2 to 2½ liters of urine daily to clear their blood of nitrogenous waste products. Primary water depletion is not as common as primary salt depletion in ordinary clinical practice, but it occurs in patients with practically complete stricture of the esophagus, in patients who have been in coma for two or three days, and in those who because of extreme weakness are unable to sit up and drink adequate amounts of water. Primary water depletion may be more common in aged, debilitated patients than is generally recognized These patients have dryness of the mouth and progressive weakness and, if not treated properly, may develop mania or coma. In this state the need of the body is for water; usually very little salt is required.

In primary salt depletion there usually is an abnormal loss of salt from the body with an adequate water intake. This salt loss occurs in excessive vomiting from intestinal obstruction, in continued gastric suction, and in diarrhea or alimentary tract fistulas. In this condition the extracellular fluid tends to become hypotonic This is especially true in those patients with gastric suction who are allowed large amounts of water to drink Since the kidneys will not retain water without salt until the salt loss is severe, depletion of body water occurs, even though adequate amounts of water are drunk The kidneys exert themselves to combat hypotonicity of the body fluids and continue to excrete water but practically no salt, and even when total body salt has been depleted, plasma chloride concentration may remain relatively normal for some time. It falls only when the kidneys can no longer excrete enough extracellular water to compensate for the salt loss When the plasma chloride concentration does fall, the reduction of body water may

and sodium chloride and other solids so accurately to intake that the volume and electrolyte concentration of the extracellular fluid are kept extraordinarily constant, providing the cells with the "internal environment" of Claude Bernard. For body cells to function normally, the volume of extracellular fluid must be kept adequate and the composition and pH must be kept within physiologic limits. Thus, the water balance is regulated nicely in normal persons ingesting food and drinking ordinary amounts of water.

When either water or salt intake is low, as in patients with dysphagia or those so weak they cannot drink adequate amounts of fluid, or when extra renal loss is excessive (as in patients with profuse sweating, excessive vomiting, gastric suction, diarrhea, or bowel fistulas), isotonicity of the body fluids is safeguarded by a de-

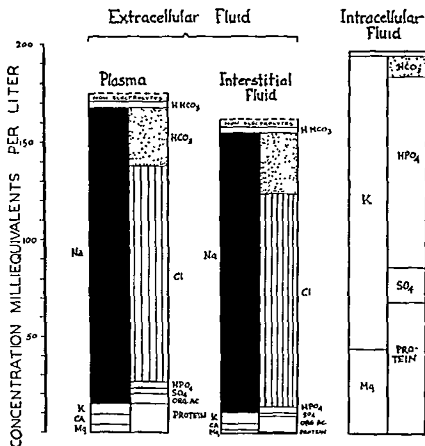


Fig 24—Composition of body fluid compartments of normal man. (After Gamble.)

This diagram illustrates that the chief cation inside the cell is potassium; outside the cell, sodium The chloride anion is chiefly in the extracellular fluid The sums of the cations and anions are approximately equal. These are shown as milliequivalents, rather than milligrams per 100 c c Such expression allows quick decision of the state of body fluid equilibrium from chemical data

To convert milligrams per cent to milliequivalents:

$$Na = \frac{mg\ \% \times 10}{23} \times 1 = mEq\ Na$$

$$K = \frac{mg\ \% \times 10}{39} \times 1 = mEq\ K$$

$$Cl = \frac{mg\ \%\ as\ Cl \times 10}{35} \times 1 = mEq\ Cl$$

$$CO_2\ combining\ Capacity = \frac{Vol.\ \%}{2.2} = mEq\ HCO_3\ per\ liter$$

$$Cl\ from\ \%\ NaCl = \frac{Value \times 10}{58} \times 1 = mEq\ Cl$$

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In primary water depletion the extracellular fluid tends to become hypertonic, although this tendency is compensated for by two mechanisms: water moves from the cell into the extracellular space, and the kidneys diminish their water output to the minimum obtainable by tubular reabsorption. Even though intracellular dehydration is marked, there may be no great change in either the plasma volume or electrolyte concentration. In this condition one may find a small urine volume and normal or increased concentration of plasma, protein, and electrolytes. A marked decrease in water excretion in primary water depletion can occur with very little change in plasma concentration

Primary water loss is best replaced by the administration of water and no salt, as 5 to 10 per cent dextrose in water. If sweating is responsible for a major portion of the water loss, replacement of salt should be by hypotonic salt solution. A suitable hypotonic salt solution is obtained by combining 0.9 per cent sodium chloride solution and 5 per cent dextrose in water. The urine output is a fairly good guide to the amount of water required and a daily urine output of 800 to 1,000 c.c. is adequate for patients with normal kidney function. Patients with diminished renal concentration power may have to be given much larger amounts of fluid to correct primary water depletion and may have to excrete as much as 2 to 2½ liters of urine daily to clear their blood of nitrogenous waste products. Primary water depletion is not as common as primary salt depletion in ordinary clinical practice, but it occurs in patients with practically complete stricture of the esophagus, in patients who have been in coma for two or three days, and in those who because of extreme weakness are unable to sit up and drink adequate amounts of water. Primary water depletion may be more common in aged, debilitated patients than is generally recognized These patients have dryness of the mouth and progressive weakness and, if not treated properly, may develop mania or coma In this state the need of the body is for water; usually very little salt is required.

In primary salt depletion there usually is an abnormal loss of salt from the body with an adequate water intake. This salt loss occurs in excessive vomiting from intestinal obstruction, in continued gastric suction, and in diarrhea or alimentary tract fistulas In this condition the extracellular fluid tends to become hypotonic. This is especially true in those patients with gastric suction who are allowed large amounts of water to drink. Since the kidneys will not retain water without salt until the salt loss is severe, depletion of body water occurs, even though adequate amounts of water are drunk. The kidneys exert themselves to combat hypotonicity of the body fluids and continue to excrete water but practically no salt, and even when total body salt has been depleted, plasma chloride concentration may remain relatively normal for some time. It falls only when the kidneys can no longer excrete enough extracellular water to compensate for the salt loss. When the plasma chloride concentration does fall, the reduction of body water may

little, if any, transfer of these cations from one space to the other. Under certain conditions of dehydration and salt deprivation or loss, transfer of some of the cell potassium to the extracellular space may occur, to be replaced under conditions of routine saline therapy by the ingress of sodium from the plasma or interstitial fluids to the cell. As pointed out above, the inordinate loss of body fluids by prolonged vomiting or diarrhea leads to considerable wastage of sodium and chloride. To these losses should be added a considerable loss of potassium. Gastric, biliary, and *intestinal fluids may contain large amounts of potassium. When sodium and potassium are lost from the body*, the normal kidney tends to conserve sodium by almost complete tubular reabsorption of that ion; the excreted urine contains almost no sodium Unfortunately, no such renal mechanism acts to conserve body potassium, so even in states of severe potassium depletion this cation continues to be lost in the urine This loss may be increased by the excessive administration of sodium, by the stress of accidental or surgical trauma, and by the alkalotic state accompanying salt depletion If replacement therapy ignores this potassium loss, potassium deficiency to some degree will develop.

The signs of extreme potassium deficiency are muscular weakness, paralysis of accessory respiratory muscles, aphonia, and coma. A diagnosis of potassium deficiency is confirmed by characteristic electrocardiographic findings. A serum potassium level of 2.6 mEq. or below is diagnostic. Commonly, the diagnosis of mild to moderate potassium deficiency in the surgical patient is posed upon an intelligent evaluation of the clinical state likely to be associated with such a deficiency. Dehydration and salt loss produced by prolonged gastric suction, excessive vomiting, diarrhea, etc., commonly lead to potassium deficiency. The associated sodium deficiency has most often been corrected by administration of fluids containing only sodium chloride and water. The subsequent dilution of extracellular fluid often accentuates the potassium deficiency. If alkalosis persists in patients after adequate hydration and sodium chloride therapy, potassium deficiency is to be strongly suspected The diagnosis may be confirmed by analysis of the plasma for potassium, but this requires a flame photometer. The surgeon is advised strongly to suspect potassium deficiency in surgical patients who have suffered excessive losses of body fluids either before or after operation, especially when alkalosis persists after adequate water and sodium chloride replacement.

In severe potassium deficiency it may be necessary to administer rapidly fairly large amounts of potassium. Ringer's solution is inadequate for this therapy because it does not contain enough potassium The emergency treatment of severe potassium deficiency requires considerable clinical and chemical judgment. If the state of renal function is not known, potassium infusions should be preceded by the intravenous infusion of approximately 800 c.c. of 5 per cent dextrose in water to stimulate urine flow. The important matter is to administer the first few grams of potassium chloride over a period of one to two hours; this usually takes care of the emergency phase of potassium replacement. Four to five grams of potassium chloride is given in one liter of 5 per cent dextrose in water for emergency treatment After this, potassium replacement may be less rapid, care being taken to administer from 2 to 5 grams of potassium chloride per day, above the calculated daily loss. Once the plasma bicarbonate content has fallen to normal levels and alkalosis is corrected, one can usually conclude the potassium problem has been corrected Oral administration of potassium chloride should be begun as soon as

possible. Potassium chloride may have to be given in amounts as high as 5 to 10 grams per day orally for some days before potassium depletion is corrected.

If at all possible, potassium chloride should be administered by the oral route, the intravenous route being used only when the patient cannot take or retain it when administered orally. Great caution is advised against the possibility that strong solutions of potassium chloride may be administered rapidly by vein. Some hospitals supply small vials containing about 40 to 100 c.c. of 10 per cent potassium chloride, to be diluted at the bedside. This practice can be dangerous unless one is confident such concentrated solutions will not be administered intravenously without proper dilution.

Water, sodium, and potassium deficits can be prevented by intelligent pre- and postoperative care of the surgical patient. Gastric and intestinal drainage should be replaced with adequate amounts of water, sodium, and potassium. Wangensteen drainage of the gastrointestinal tract should be stopped as early as possible in the postoperative period, and the patient then should be encouraged to eat.

The recognition of potassium as well as sodium deficiency in surgical patients has led to the development of more balanced solutions for saline infusions in surgical patients. Accordingly, many investigators now agree that we should largely abandon the routine use of so-called physiologic saline solution in surgery and use instead a balanced solution containing adequate amounts of potassium and sodium salts. There is more or less agreement that the sodium chloride content of these solutions should be about 0.6 per cent with potassium chloride added to make the solution isotonic. The solution advocated by Fox is as follows:

Na	140 mEq
Cl	103 mEq
HCO_3	55 mEq
K	10 mEq
CO	5 mEq
Mg	3 mEq
H_2O	1 liter

The solution accepted for standard use in all Scandinavian countries has the following composition:

Potassium and Sodium Chloride	
KCl	3.8 grams
$Na_2HPO_4 2H_2O$	12 0 grams
$NaH_2PO_4 2H_2O$	0 3 gram
NaCl	5 4 grams
H_2O to one liter	

Randall has used a balanced solution made up as Na—110, K—30, and Cl—140, all concentrations as milliequivalents per liter of water. If these solutions are used for replacement therapy in an intelligent manner, they should help prevent both sodium and potassium deficiency. Nevertheless, when potassium losses are large, the surgeon will have to add as much as 2 to 5 grams potassium chloride per liter of 0 6 per cent sodium chloride solution to correct potassium deficiency.

If moderate to extreme acidosis exists, Ringer's lactate solution may be used and given in amounts suggested by Van Slyke to correct the acidosis. It is wise, however, to make a trial of giving only approximately one-half the amounts of Ringer's lactate calculated by the Van Slyke formula and to run a record plasma

bicarbonate determination before the entire calculated amount is administered. In some patients it was found that unless this was done, excessive amounts of Ringer's lactate would have been employed to correct the acidosis.

Certain patients require almost continuous fluid and salt therapy before and after operation if the salt and water losses have been severe or continue to be large. It is most helpful to insert a polyethelene tube into a suitable vein for this therapy. A supply of sterile polyethylene tubing of various sizes should be kept in 1:1,000 Zephiran solution for this purpose. When the tubing is employed according to the suggestions of Diamond and others, a solution can be kept running into the same vein for as long as five or six days. This greatly facilitates intravenous therapy.

A final word of caution should be given about fluid and electrolyte therapy in the surgical patient. Replacement therapy for adequate fluid balance should never be routinely ordered. Such orders should be written only after careful chemical and clinical appraisal of the patient's needs All patients requiring Wangensteen drainage should be given only the type and quantity of fluid and salt needed. This requires daily quantitative measurements of gastric drainage and urine volumes, and these results must be known to the surgeon before he orders fluids for the day. To these amounts of water and salt he adds that required to replace insensible loss or that lost from fistulas. If the fluid and salt balance problem is especially complicated, frequent blood chemical examination for plasma chloride, bicarbonate, and sodium and potassium is required.

Only those surgical patients with abnormal losses of salt and water require intravenous fluid and salt therapy. This means that it is unnecessary to administer parenterally salt and water to the average patient who has had a simple herniorrhaphy, appendectomy, etc. These patients will not suffer from water and salt depletion as the result of an eight- to twelve-hour fast.

The surgeon should plan to use the waking period of the day for intravenous therapy. *Fluids containing the necessary salts should be given early in the day, so* the patient can have untroubled sleep. Wangensteen gastric drainage should be stopped as soon as possible, and the patient should be given solid, appetizing food Patients who can eat rarely have problems of fluid and electrolyte balance.

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CHAPTER 6

ANESTHESIA

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It is not possible in the limited space available to present in detail the large number of anesthetic technics currently in use An attempt is made to supply information which will help surgeons decide the type of anesthesia best suited for various operations and conditions. Although there have been remarkable advances in anesthesiology during the past decade, surgeons still are confronted with all degrees of skill in this field. If he does not have confidence in his anesthetist, the surgeon may gain some comfort through familiarity with the fundamentals of anesthesia.

Although there are a number of anesthetic agents available, none are perfect; all have advantages and disadvantages; one agent alters body physiology in a different manner from another. A technic suitable for use in one condition or operation may be contraindicated in certain other conditions Surgeons and anesthetists tend to develop unqualified enthusiasm for some particular anesthetic agent or technic and to use it indiscriminately It is better to select an agent or a combination of agents which are productive of minimum disturbances in body physiology and are best suited for use in the condition under consideration. At the same time it must be admitted that all anesthetists are not equally capable in the administration of all the available anesthetic agents. Generally speaking, it is not the agent but the ability of the anesthetist to administer it which determines the safety of the patient It is unsafe for an anesthetist to employ an anesthetic agent or technic with which he is unfamiliar, and it is unwise for the surgeon to urge him to do so

PREOPERATIVE MEDICATION

All patients coming to operation should have sufficient preoperative medication to secure sedation without undue depression. There are both advantages and disadvantages for all of the drugs used for preanesthetic medication, but the advantages of certain ones far outweigh the disadvantages.

Barbiturates

These drugs are hypnotics; adequate dosage will produce sedation without depression of vital body functions; there is a slight decrease in respiratory exchange due to the quieting effect on the patient. Because it is not desirable to prolong the effect of preoperative medication beyond the operative period, one of the short-acting barbiturates should be used. An exception to the usual action of barbitu-

rates may occur in elderly individuals, so that a marked depression of respiration results. In such patients the dose should be scaled down or the drug should be eliminated entirely from the preoperative schedule. Children may be given Pentothal Sodium by rectal administration. A dosage of 10 to 20 mg. per pound of body weight will usually result in sleep in fifteen or twenty minutes and last for about two hours. Their condition during this period is usually satisfactory.

Opiates

Morphine is particularly valuable preoperatively. In addition to analgesia, the administration of this drug results in somnolence and euphoria. Morphine is a depressant of the medullary respiratory center, and consequently the dosage must be suited to the individual patient. The dosage must be decreased in elderly or debilitated individuals, or small doses of Demerol may be substituted for morphine. Demerol produces analgesia, sedation, and euphoria, and has some atropine-like action. It also mimics papaverine in relaxing smooth muscle. It is frequently recommended as a sedative in elderly individuals since it is thought not to produce as pronounced respiratory depression as does morphine.

Atropine and Scopolamine

These drugs have two actions which are useful preanesthetically; the first is that of drying the glandular secretions of the respiratory tract. In this respect the action of scopolamine is more pronounced than is that of atropine. Secondly, the parasympathetic autonomic nerves to the heart and respiratory tract are depressed by the action of these drugs, especially by atropine; this decreases the depressant action of the vagus nerves on the heart rate and inhibits the constrictor effect of these nerves on the musculature of the respiratory tract. In addition to this autonomic blocking effect of atropine and scopolamine, there is an effect on the central nervous system. Atropine produces some stimulation of higher cerebral centers and also of the medulla, so that there is a little increase in respiration and metabolism. The action of scopolamine on the central nervous system is one of sedation and the production of drowsiness and retrograde amnesia. An occasional patient may exhibit restlessness or delirium after administration of scopolamine, and this is especially true if it is given in the presence of pain.

Atropine has a wide margin of safety. It causes suppression of sweating so that the skin becomes hot and dry. In children the administration of atropine is sometimes followed by flushing of the skin and elevation of temperature. Ordinarily this is not serious, but in toxic and dehydrated children it may be so.

The time of administration of preanesthetic medication is of great importance; it should be given one hour before the time of operation in order to secure the desired result. Because these drugs have a length of action of two or three hours, it is much better to give them too early than too late. If it is not possible to give them a sufficient length of time before the operation, they should be given intravenously. Atropine or scopolamine and morphine may be combined and when given intravenously the effect will begin in a few minutes. No greater depression results from the intravenous administration of opiates than from their subcutaneous administration; the analgesic effect is somewhat less pronounced.

Premedication is as valuable in children as it is in adults, but careful dosage must be selected in order to achieve the desired effect without causing undue depression. The following doses of morphine and Nembutal are well tolerated by children:

Nembutal (Oral Admin.)		*Morphine* (Hypo.)	
9 mo.-2 years	½ gr.	3-5 years	1/48 gr.
2-4 years	¾ gr.	5-7 years	1/24 gr.
4-7 years	1 gr.	7-10 years	1/18 gr.
7-11 years	1½ gr.	10-12 years	1/12 gr.

INHALATION ANESTHESIA

The adverse effects of inhalation anesthesia are in large measure due to inadequate oxygenation and failure to eliminate carbon dioxide properly. There are grades of anoxia and carbon dioxide retention. Severe anoxia attracts attention and usually is promptly corrected, but the less pronounced states may not be recognized and corrected, with serious results. The deeper the anesthesia, the less chance there is for the protective respiratory reflexes to aid in correcting the difficulty. Cyanosis or the lack of it is not a satisfactory indication as to the state of oxygenation, because cyanosis becomes apparent with different degrees of oxygenation in different individuals. Moreover, obvious cyanosis indicates a marked degree of oxygen desaturation, and a lesser degree of anoxia may cause serious difficulty if allowed to persist. Carbon dioxide is toxic in any except low concentrations. A respiratory center depressed by preoperative sedation plus the anesthetic agent may fail to respond to carbon dioxide concentrations far above the safe level. When high concentrations of oxygen are used, as is the case when such anesthetic agents as ether or cyclopropane are employed, there may be adequate oxygenation even though the respiratory exchange is much reduced. However, under such circumstances carbon dioxide elimination is almost certain to be inadequate. Controlled or manually augmented respiration is necessary to correct this

Adequate oxygen content in the inspired air and adequate respiratory exchange are necessary. The latter is assured only when there is a completely unobstructed airway. Oxygen absorption and carbon dioxide elimination are seriously interfered with by conditions which are of frequent occurrence during anesthesia, such as relaxation of the tongue or pharyngeal structures, laryngospasm, or a collection of blood or mucus in the respiratory passages. Impairment of the airway also reduces intrapleural pressure and thereby increases the likelihood of pulmonary edema.

Complications of Inhalation Anesthesia

Accidents occurring in connection with inhalation anesthesia usually are due to an overdose of the anesthetic agent or to obstruction along the respiratory tract. A not infrequent cause of respiratory obstruction is the aspiration of vomitus. The vomitus must be removed promptly by aspirating the air passages, and this is most effectively accomplished by bronchoscopy. Acid gastric contents are apt to cause severe pneumonitis if not thoroughly removed. Precautions must be taken to prevent the aspiration of foreign bodies, such as dentures or chewing gum.

Laryngospasm may be initiated by the aspiration of regurgitated material, a not unlikely occurrence when curare is used. Laryngospasm also may occur when

manipulation, such as attempts to insert a tube, are carried out under light anesthesia. Attempts to intubate patients who are under Pentothal anesthesia are especially prone to produce laryngospasm, for the drug is not potent enough to establish an adequate level of anesthesia to withstand such stimulation. In any event, laryngospasm may lead to a very serious degree of anoxia which must be treated by aspirating excess secretions or regurgitated material, then administering oxygen under pressure by a face mask. It may be necessary to intubate the patient to relieve the obstruction and usually it will be necessary to deepen the anesthesia for intubation. Curarization will relax the laryngeal musculature.

Patients who have partial respiratory obstruction due to external pressure on the larynx or trachea will likely become completely obstructed if given a general anesthetic It is therefore advisable to insert an endotracheal tube, using topical anesthesia, preliminary to the administration of a general anesthetic Postoperative atelectasis may occur after general, local and regional, or spinal anesthesia. Any one of the following factors or combination of factors may cause atelectasis: depression of or interference with respiration; "splinting" because of painful wounds; depression of the cough reflex from preoperative or postoperative medication, or by the anesthetic; abdominal distention with elevation and fixation of the diaphragm; and interference with the action of the cilia of the respiratory mucosa. The final cause in the majority of cases is bronchial obstruction by plugs of thick mucus.

Aspiration by means of an endotracheal catheter initiates effective coughing and may clear up the atelectasis. Inhalation of a mixture of 5 per cent carbon dioxide and 95 per cent oxygen may be used in conscious patients to produce deep breathing and coughing. Thumping the chest wall over the affected area is sometimes effective. However, if these measures are not effective within the first few hours, bronchoscopy with aspiration may be advisable. As a rule, aspiration is not effective after twenty-four hours.

Pneumonitis also may follow the aspiration of foreign material; an example is the severe pneumonitis which may occur after the aspiration of gastric contents. Depression of respiration and of the cough reflex sometimes eventuates in pneumonitis or pneumonia, but the initial lesions are areas of lobular atelectasis which coalesce. In the early stages it may not be possible to distinguish, by physical examination or by roentgenograms, pneumonia from lobular atelectasis In any event, vigorous measures directed toward clearing up the atelectasis may prevent the development of pneumonitis or pneumonia

Reflexes activated by stimulation of the autonomic nervous system may be troublesome during certain operations Traction on the gall bladder or stimulation of the celiac ganglion may cause a slowing of the pulse and a short transient fall in the systolic blood pressure, resulting in a very narrow pulse pressure. Such effects may be reduced or even prevented by deepening the anesthesia Pressure over the carotid sinus during cervical operations not infrequently produces bradycardia and a precipitate fall in blood pressure This effect may be prevented by administering ether or by procaine block Pentothal and cyclopropane are ineffectual in this respect

All anesthetic agents may produce cardiac arrhythmias, many of which are of little significance Significant arrhythmias are often encountered when high concentrations of cyclopropane are used in attempts to secure greater relaxation. The administration of Adrenalin during cyclopropane anesthesia will likely result in ven-

tricular fibrillation. Chloroform is known to cause ventricular fibrillation and so does ethyl chloride. A slow, weak, and irregular pulse is produced in certain individuals by intrathoracic manipulation, especially manipulation at the hilum of the lung. When serious arrhythmias occur, the anesthetic should be temporarily discontinued and a high concentration of oxygen must be given. One hundred milligrams of procaine intravenously is sometimes effective Atropine, 1/100 to 1/150 grain, usually will improve the circulation by increasing the heart rate if that has become abnormally slow. Along with cardiac dysfunction, respiration is affected and must be aided or controlled as seems necessary.

Choice of Agent

All anesthetic agents produce some undesirable effects, and each of them has characteristic qualities which should be taken into consideration in connection with specific anesthesia problems. Ether is often described as the safest anesthetic agent, but consideration of the numerous adverse effects indicates this is not always the case. However, *ether is the safest anesthetic agent for use by inexpert anesthetists* and has a wider range of usefulness than any of the presently employed anesthetic agents. The open drop technic of administration may be safer in untrained hands but has disadvantages, often unrecognized. Low-grade anoxia frequently develops, and carbon dioxide retention is not uncommon. When ether is administered by machine with the closed circuit technic, it is possible to control reflexes and obtain adequate relaxation and yet avoid anoxia. Since ether blocks the inhibitory effect of the vagus nerve on the heart, it is well suited for use on patients who have cardiac arrhythmias. Ether was formerly considered a poor anesthetic for use in patients with pulmonary infection, because it is irritating and increases the bronchial secretions, but when well administered, ether compares favorably with other inhalation anesthetics in such cases.

Cyclopropane is not irritating and causes no special increase in bronchial secretions, so it is well suited for use in the presence of pulmonary disease. Relaxation may be secured by supplementing cyclopropane with curare or with small amounts of ether. The ether also affords considerable protection against the toxic effects of cyclopropane on the heart. Since cyclopropane is a potent anesthetic agent, it is useful in individuals who are difficult to anesthetize. Cylopropane also is suitable for use in many poor-risk patients since it produces comparatively little upset in body metabolism Cyclopropane is a parasympathomimetic stimulant and is therefore unsuited for use in patients with bronchial asthma. Ether, a sympathomimetic stimulant, is the inhalation anesthetic agent of choice in such cases.

Nitrous oxide and ethylene are not sufficiently potent to produce satisfactory anesthesia except by reducing the oxygen content of the mixture below a safe level. Both nitrous oxide and ethylene are useful for supplementing other more potent agents and produce no deleterious effects when so used. When used alone for minor procedures, adequate preliminary medication may make the difference between success and failure When these gases are mixed with oxygen, the flow must be measured in liters rather than in cubic centimeters to maintain the desired concentration of oxygen, which is being constantly absorbed while the anesthetic gases are inert.

Vinethene and ethyl chloride are useful for the induction of anesthesia in children or for very short procedures. Both of these agents are potent and act rapidly,

	ETHER	VINETHENE	CYCLOPROPANE	NITROUS OXIDE	ETHYLENE
Physical characteristics	Explosive; free of impurities in corked container	Explosive; unstable after opening	Explosive, sweet odor	Not explosive but will burn in an explosive mixture; sweet odor	Explosive; unpleasant odor
Local effect on respiratory tract	Irritation, secretions increased	Irritation; increased mucus	Minimal in anesthetic concentration	No irritation	No irritation
Vomiting center	Stimulation in upper planes of anesthesia	No stimulation	Stimulation	Some stimulation	Some stimulation
Respiration	Stimulation initially, then gradual depression, respiratory arrest with 7 volume per cent	Respiratory arrest before circulatory failure, at 10% by volume, depressed in deep anesthesia	Depression; respiratory arrest before circulatory failure	Slight stimulation	Slight stimulation
Blood pressure	Progressive decrease in deep anesthesia	Depressed in deep anesthesia	No decrease	No effect	No effect
Heart	Arrhythmias not very significant; inhibitory center depressed	No significant change	Rate slowed. Arrhythmias frequent; addition of Adrenalin may cause fibrillation	No effect	No effect
Liver function	Depression, usually temporary, hepatitis has occurred, glycogen depleted	Central necrosis after long or repeated anesthesia	No effect	No effect	No effect
Kidney function	Depressed	No suppression	Temporary suppression	No effect	No effect
Blood	Clotting time decreased 25%, bleeding time unchanged	Bleeding and clotting time unchanged	Bleeding and clotting time unchanged. Dilatation of peripheral arterioles	Clotting time slightly increased	Clotting time decreased Bleeding time slightly increased
Muscular relaxation	Satisfactory	Not complete	Not complete	No relaxation	No relaxation
Metabolism	Depressed Temperature regulating center depressed. Blood sugar increased 200 per cent	Slightly increased blood sugar	Decreased	No effect	Slight effect
Potency	100% anesthetic*, surgical anesthesia with 3½ volume per cent	100% anesthetic; anesthesia with 4% by volume, rapid acting	100% anesthetic; surgical anesthesia with 20-25% by volume	15% anesthetic; 85-90% by volume for anesthesia	15-20% anesthetic; 80-90% by volume for anesthesia

*A 100 per cent anesthetic is one which is potent enough to carry a patient through all the stages of anesthesia to respiratory arrest by its own action

Fig. 25.

so that a deep level of anesthesia may be reached after only a few deep breaths. This is especially true of ethyl chloride. Ethyl chloride is capable of producing ventricular fibrillation, a serious disadvantage. Muscular tremors and convulsions may occur with Vinethene because of its effect on the spinal cord. Vinethene, if used repeatedly or for prolonged anesthesia, may cause central necrosis of the liver lobules and should not be so used.

Chloroform, because of its low volatility, continues to be used by the open drop technic in hot climates; but, because of the many dangers associated with it, its use should be condemned.

A chart (Fig. 25) shows the different properties and effects of the most frequently used inhalation anesthesia.

ENDOTRACHEAL ANESTHESIA

There are many indications for the use of endotracheal anesthesia and relatively few contraindications. Inexperience and inability on the part of the anesthetist to intubate without undue trauma is a relative contraindication. Inflammatory or neoplastic lesions in the larynx or trachea are contraindications. Tubercle bacilli in the sputum may at times be considered a contraindication since trauma to the laryngeal mucosa might predispose to the development of laryngitis. An aortic aneurism pressing against the trachea is a contraindication because of the danger of rupturing the aneurism. In certain blood dyscrasias with pronounced tendency to bleed, the introduction of an endotracheal tube may cause continued bleeding into the air passages. Intubation of very young infants not infrequently causes laryngeal edema if inexpertly done.

With proper management an endotracheal tube insures an unobstructed airway and provides a greater measure of control of the patient's respiration than one can obtain by any other means. With a suitable tube in place, the anesthetist can avoid anoxia and carbon dioxide retention, and even when the thorax is opened wide he can control the degree of expansion or collapse of the lungs When used for upper abdominal operations, breathing is quiet and efficient and one obtains greater relaxation than could otherwise be had with the same plane of anesthesia. During certain operations and when certain anesthetic agents are used, the respiration must be augmented or even controlled, and this can be satisfactorily accomplished *only* by the use of an endotracheal tube Tubes with inflatable cuffs prevent blood and mucus from entering the bronchial tree and permit aspiration of it.

There are disadvantages associated with the endotracheal technic, but rarely are they sufficiently important to contraindicate its use. Anatomical variations may make intubation difficult, and trauma to the larynx is then likely. Difficult intubation may require several attempts before the tube is successfully introduced, and this results in anoxia. Intubation may be followed by prolonged apnea and rarely by cardiac standstill, presumably the result of inhibitory reflexes initiated through the autonomic nervous system These reflexes apparently are more likely to occur if intubation is attempted in too light a plane of anesthesia. Benign laryngeal polyps sometimes occur after endotracheal intubation, but the incidence is low. To permit intubation, a deeper plane of anesthesia is necessary at that time than might otherwise be required. Even with a tube in place, kinking of the tube or the collection of blood and mucus in the tube may interfere with respiration and must be avoided.

INTRAVENOUS ANESTHESIA

In this country, at the present time, intravenous anesthesia usually refers to anesthesia from Pentothal Sodium. Intravenous anesthesia is especially acceptable to patients, since it is a most pleasant way of inducing sleep.

Pentothal Sodium has the advantages of ease of administration and simplicity of required apparatus. However, these very advantages have resulted in abuse of the method. When the inhalation agents are used, the establishment of a suitable plane of anesthesia obviously requires some training and skill, but the administration of the anesthetic agent by vein seems a simple matter. However, once the agent enters the blood stream, the anesthetist has much less control of the situation than when inhalation agents are being used. The latter agents are constantly being returned to the lungs by the blood and thus are eliminated from the body quite rapidly. The nonvolatile drugs, such as Pentothal, are disposed of much more slowly. Also the rate of detoxification of Pentothal varies greatly in different patients, depending to a considerable extent on the physical status.

Pentothal produces cerebral depression, but reflexes initiated by surgical or other manipulation are not obtunded. Muscle relaxation is not produced, so when this is required, another agent must be used, or a drug such as curare may be used concomitantly to produce the relaxation. After Pentothal induction, ether and oxygen may be used for relaxation.

The respiratory center in the medulla is depressed by Pentothal and the minute volume of respiration is decreased, so oxygen should always be given Proper doses of Pentothal ordinarily have no significant effect on blood pressure or pulse, but large doses of any of the barbiturates are said to depress the vasomotor center. Also a dose of Pentothal which will not produce such an adverse effect in healthy individuals may result in serious circulatory depression in less rugged individuals. Large doses of Pentothal may cause pulmonary edema

While there is no conclusive evidence that Pentothal causes further damage to the liver in patients with hepatic disease, it has been observed that in such cases the period of depression caused by that drug is apt to be prolonged. Pentothal causes a slight rise in blood sugar.

There are a number of contraindications to the use of Pentothal: It must never be given when there is respiratory obstruction; Pentothal results in very quiet respiration so respiratory obstruction may go unnoticed unless it is especially looked for, laryngospasm may occur and may not be detected by casual observation. Where there is danger of the accumulation of blood or mucus in the pharynx, as occurs in operations on the mouth, throat, and nose. Pentothal must not be used without the concomitant use of an endotracheal tube.

Some anesthesiologists consider myocardial disease with a decrease in cardiac output a contraindication to Pentothal It does not appear to be an acceptable anesthetic in shock cases. In shock patients and also in patients with marked anemia, very marked depression may result from its use

Vomiting rarely occurs during Pentothal anesthesia, but regurgitation of stomach contents does occur and is a major hazard.

Careful observation is necessary during the recovery period. "Respiratory collapse" following Pentothal anesthesia is practically always due to respiratory obstruction from such causes as the tongue falling back into the pharynx, or laryngo-

spasm due to an accumulation of secretions in the pharynx. When significant respiratory depression occurs during operation, the patient should not be returned to the ward until it is certain that respiration can be maintained without assistance and without the administration of oxygen.

Sometimes "just a little Pentothal" is requested for short cases involving individuals who are not suitable candidates for the drug. There is no such thing as "a little Pentothal" for anesthesia, for when a sufficient amount has been given to permit any operative procedure, enough has been given to destroy protective reflexes, thereby setting the stage for an accident.

Technic of Administration

Pentothal is best used as a 2½ per cent solution, and a satisfactory technic is to inject 2 c.c. of this solution a minute. The respiration is the best indicator of the depth of anesthesia and therefore must be observed with the greatest care. The respirations decrease in rate and amplitude as the depth of anesthesia increases. During the administration of Pentothal, there frequently are periods of apnea; during such periods administration of the drug should be discontinued until it is certain that spontaneous respiration will recur. With these precautions, the injection is continued until the desired level of anesthesia is reached.

RESUSCITATION

Anesthesia accidents occur, even under the best of circumstances, but catastrophes usually can be prevented by prompt and efficient action. Regardless of the type of anesthetic accident, the ultimate cause of injury to the patient is anoxia. Practically speaking, there is no oxygen reserve in the body. The ability of the various body cells to withstand anoxia no doubt varies with the attending circumstances, but the cells of the cerebral cortex are always vulnerable.

There are two essentials in resuscitation: oxygenation and the maintenance of an adequate circulation The most effective means of oxygenating such a patient is the most direct and obvious one, the administration of oxygen through an intratracheal tube. If this is not possible, a tightly fitted mask should be used Intermittent expansion of the lungs may be accomplished by manual compression of the bag or by a machine designed for that purpose The various respiratory stimulants, such as Coramine, are of little or no value under the conditions now being discussed.

Since promptness in reestablishing oxygenation and an adequate circulation is absolutely essential, suitable equipment must be immediately at hand. Fortunately nothing elaborate is required. The anesthetist must be certain the patient has an unobstructed airway. The ordinary rubber airway used in anesthesia is adequate to prevent obstruction by the tongue if a mask is being used. Although an endotracheal tube provides the best means of giving oxygen and prevents the stomach from being distended with gas, it is better to have a live patient with a distended stomach than to risk delay in oxygenating the patient After the immediate danger has passed, the stomach may be deflated by a gastric tube.

Depression of circulation must also be treated promptly by intravenous infusion of fluids or blood, whichever is indicated. If a vasopressor drug is indicated, 20 mg. of ephedrine intravenously usually will be effective. The interrelationship between the circulation and respiration is such that when there is sudden cessation of one,

the other will be affected within a matter of seconds. The time factor is especially vital when there is cardiac arrest or ventricular fibrillation. As soon as such a diagnosis is made, the anesthetist must begin rhythmic inflation of the lungs with 100 per cent oxygen at a rate of about 20 times a minute. Cardiac massage provides sufficient circulation to maintain viability of the brain cells if the blood is fully saturated with oxygen. When there is doubt that the anesthetist will be able to provide adequate ventilation by manual compression for a long period, a mechanical device for rhythmic compression of the rebreathing bag is advisable.

SPINAL ANESTHESIA

Since the introduction of spinal anesthesia, there have been waves of enthusiasm for or dissatisfaction with the method and marked differences of opinion as to its usefulness. Following the initial enthusiasm for spinal anesthesia, it fell into disfavor because the available drugs were unsafe for such use and also because of a lack of understanding of the physiologic effects produced by blocking the spinal nerves. Since then a number of more satisfactory drugs have been introduced and much has been done toward perfecting the technic of administration of spinal anesthesia. Also a better understanding of the alterations in body physiology has been acquired, and methods have been developed for proper prevention and control of certain of the more important physiologic changes. A better understanding of the problems connected with spinal anesthesia has helped temper enthusiasm for it and dissatisfaction with it.

Pharmacology

Drugs for spinal anesthesia usually are employed as water-soluble hydrochlorides. When these are injected into the subarachnoid space, the more alkaline spinal fluid liberates the free base, the anesthetic agent. Some failures of spinal anesthesia are reportedly due to the fact that the pH of the spinal fluid is such that the anesthetic substance is not released. When a drug is injected intrathecally, its concentration rapidly diminishes, first by dilution and then as a result of fixation by nerve tissue or through vascular absorption. With the onset of anesthesia, the sensations of light touch, pain, temperature, pressure sense, and motor function are blocked in that order, and functions return in the reverse order. The basis for this apparently is that the drug acts first on unmyelinated nerve fibers. The spinal nerves, the nerve tracts in the spinal cord, and the sympathetic fibers apparently are all affected. Part of the fall in blood pressure at the onset of spinal anesthesia is due to interference with the vasoconstricting action of the sympathetic nerves. As vasodilatation occurs in the area of anesthesia, compensatory vasoconstriction takes place in the unaffected areas and this tends to stabilize the blood pressure. Low spinal anesthesia results in little blood pressure change in normal individuals because of this compensatory action, but the higher the level of anesthesia, the smaller is the area of the body in which compensatory vasoconstriction can occur and the greater is the tendency for the blood pressure to fall. When the sympathetic cardioaccelerator nerves in the thoracic portion of the cord are blocked, the parasympathetic nerve supply to the heart functions unopposed, and this supposedly accounts for the slow pulse observed in patients with high spinal anesthesia

Indications

Success with this method of anesthesia depends largely on the proper selection of cases. Spinal anesthesia is said to be suitable for all operations below the diaphragm, but this should not be interpreted as meaning it is always the anesthesia of choice for operations in this area. Spinal anesthesia does provide excellent operating conditions because it gives such complete skeletal muscle relaxation, and when ease of exposure is of prime importance, spinal anesthesia merits consideration. Along with skeletal muscle relaxation, there is contraction of the smooth muscle of the bowel wall, and this also aids the surgeon in gaining an adequate exposure. Spinal anesthesia, essentially a form of regional anesthesia, interferes less with the body physiology than do any of the general anesthetics. It is, therefore, suitable for use in patients with liver or renal disease, as well as in those with diabetes and other metabolic disorders. Whether or not spinal anesthesia is used for operations in the upper abdomen should depend primarily on the ability of the anesthetist to institute and maintain an adequate level of anesthesia and at the same time keep the patient's circulation and respiration functioning satisfactorily. An adequate level of anesthesia is more easily obtained and the incidence of untoward reactions is less when spinal anesthesia is used for operations in the lower abdomen and pelvis and upon the lower extremities.

Spinal anesthesia has been recommended for patients with acute upper respiratory infections in whom operation is urgently required. Statistics indicate, however, that pulmonary complications occur just as frequently after spinal anesthesia as following general anesthesia.

Contraindications

Infection at the site for spinal puncture is an absolute contraindication to the use of spinal anesthesia. Diseases of the central nervous system, including the cord changes incident to pernicious anemia, contraindicate spinal anesthesia. Patients in cardiac decompensation may not have the reserve to withstand marked changes in blood pressure, and a marked drop in blood pressure interferes with filling of the coronary arteries, rendering patients with coronary artery disease unsuitable for high spinal anesthesia. Spinal anesthesia is not suitable for patients in shock or for individuals suffering from a significant degree of anemia. Patients with either of these conditions are particularly apt to show a marked fall in blood pressure under spinal anesthesia, and such hypotension is often difficult to correct. Extreme degrees of hypotension or hypertension are contraindications to spinal anesthesia. Patients with marked hypertension are particularly liable to exhibit sudden and alarming falls in blood pressure. Debilitated or cachectic individuals usually do not tolerate spinal anesthesia well.

High spinal anesthesia generally is not suitable for use in "poor-risk" cases, for the stress imposed on the circulation requires a certain degree of sthenia.

Inexperience of the anesthetist and lack of facilities to combat the immediate complications of spinal anesthesia should contraindicate its use. Necessary facilities include means for the administration of oxygen under positive pressure if it becomes necessary to take over the patient's respiration, adequate provision for giving intravenous fluids, including blood, equipment for tracheal intubation, and certain vasopressor drugs

Complications of Spinal Anesthesia

1. During the anesthesia the damage ultimately is due to anoxia:

Cardiovascular System: A fall in blood pressure may occur from decreased peripheral resistance or decreased venous return to the heart. Cardiac failure may occur from inadequate coronary blood flow and from oxygen want.

Respiratory System: A decreased minute volume of respired air or oxygen may occur because of paralysis of the intercostal nerves. Inadequate oxygenation causes depression of cerebral and medullary centers and of the myocardium. Block of the phrenic nerves with paralysis of the diaphragm occurs if there is sufficient concentration of the drug in the cervical region. This means complete respiratory failure and requires the anesthetist to breathe for the patient.

Immediate Reactions: Profound depression of all vital centers may occur as a result of the inadvertent intravascular injection of the anesthetic solution or, rarely, from individual sensitivity to the drug.

2. Postoperative complications involving the central nervous system are as follows:

Meningismus: Fever, rigidity of the muscles of the neck, and headache from local irritation by the drug.

Meningitis: Due to infection.

Headache: Apparently due to irritating effect of the drugs or leakage of spinal fluid at the puncture site.

Arachnoiditis, radiculitis, transverse myelitis, demyelinization and degeneration of the spinal cord, the *cauda equina* syndrome. Involvement of *cranial* nerves: due to chemotoxic effect or combination of this and pre-existing degenerative or virus disease.

Technic of Spinal Anesthesia

Factors which determine the level of anesthesia:

Dosage: 150 mg. procaine give anesthesia for upper abdominal surgery, because of dilution small doses do not give a high level of anesthesia.

Volume of solution: 3 to 4 c c provide a level of anesthesia in the thoracic area; 1 5 to 2 c.c. suffice for anesthesia of the perineum

SPECIFIC GRAVITY OF SOLUTIONS OF DRUGS FOR SPINAL ANESTHESIA*

	PER CENT			SPECIFIC GRAVITY
Procaine	10	(crystals in spinal fluid		1.025
Procaine	10	in distilled water	(2 c c ampules)	1.016
Pontocaine	1	in normal saline	(2 c c, ampules)	1.007
Procaine	10	—	50 mg	1 009
Pontocaine	1	—	10 mg	
Pontocaine	1	—	10 mg	1 014
Dextrose	10	—	1 c c	
Spinal fluid		—	2 c c	
Nupercaine 1 1,500 in 0 5 per cent saline				1.003
Pontocaine	1	—	1 c c	1.020
Dextrose	10	—	1 c.c	

*Specific gravity of spinal fluid 1 007

Rate of injection: 0.5 c c. per second is ordinarily a satisfactory rate.

Position of patient: with regard to baricity of solution injected.

Site of injection: less important than the other factors.

Continuous Spinal Anesthesia

Equipment

Lemmon Technic

1. Special mattress with cut-out area for needle.
2. Malleable spinal needle.
3. Rubber tubing to connect spinal needle to syringe containing anesthetic agent.

Tuohy Modification

1. Huber point needle.
2. No 3½ woven, or boilable plastic catheter.
3. Metal adapter or 23 gauge needle to connect catheter to syringe containing anesthetic agent.

Technic

1. Lemmon (original): The malleable needle remains in situ with special mattress to protect it, connected to syringe by rubber tubing.

2. Tuohy modification: No. 3½ woven, or plastic spinal catheter is inserted into subarachnoid space through the Huber point needle, which is then withdrawn; catheter is connected to syringe by a 23 gauge needle or by special adapter. Patient may be put in any position.

3. Dosage: 3 to 5 per cent procaine. Original injection is ½ to ¾ dosage used in single injection spinal anesthesia; supplemental injection consists of about 1 c.c. at 20-to 30-minute intervals depending on level to be maintained.

Management of Spinal Anesthesia

The most dangerous period is the first 20 to 30 minutes. Management includes:

1. Adequate sedation.
2. Vasopressor drug to be given before anesthesia is induced.
3. Intravenous fluids.
4. Frequent determination of blood pressure, pulse, and respiration, findings recorded at five-minute intervals.
5. Careful observation for pallor, cyanosis, sweating, difficulty in breathing or speaking.
6. Accurate determination of level of anesthesia; do not position the patient so that the level can ascend too high, until the drug has become fixed by the nerve tissue.
7. Prompt treatment of complications:
   a. Vasopressor (i.e., 20 mg ephedrine) intravenously when necessary; intramuscular route is too slow.
   b. Oxygen; augment respirations when they are inadequate or control respirations when they are suspended, by tight-fitting face mask and rhythmic compression of the rebreathing bag.
   c. Tracheal intubation for control of respiration should a major reaction occur.

d Rapid infusion of fluids or blood.

e. Raise or lower head of operating table, depending on baricity of the drug, to prevent further ascent.

LOCAL ANESTHESIA

When local anesthesia is used under suitable circumstances, it produces fewer disturbances in body physiology than any type of anesthesia. Local anesthesia is therefore especially useful in poor-risk and elderly patients. Local anesthesia is made far more effective by proper premedication. Additional sedation can be rapidly achieved, when necessary, by the intravenous administration of one of the soluble barbiturates or by the intravenous injection of a combination of scopolamine and morphine in the ratio of 1 to 25; for instance, scopolamine gr. 1/100 and morphine gr. 1/4. A local anesthetic may be used to supplement very light general anesthesia. An abdominal block, for instance, is adequate until the peritoneal cavity is entered and traction is made on the viscera; at this point the traction pain, which is transmitted by the sympathetic nervous system, can be obtunded by producing light general anesthesia with an agent such as cyclopropane or by the intravenous administration of a small amount of Pentothal Sodium

Conduction or regional anesthesia is a most satisfactory technic for inducing local anesthesia in many areas. In other areas, a combination of conduction and local infiltration anesthesia gives more reliable results.

Toxicology

All drugs used for local anesthesia are toxic, and complications may be expected to follow their use unless proper precautions are taken. The initial effect of these drugs on the central nervous system is stimulation, producing convulsions if a sufficient dosage is assimilated. This is followed by depression and then collapse. The signs and symptoms of reaction to a local anesthetic drug are nervousness, apprehension, pallor, sweating, rapid pulse becoming weak, irregular and shallow respiration, convulsions, coma, and finally arrest of respiration and circulation. Important factors in the production of such a reaction are (1) the quantity of drug injected, (2) the rate of absorption of the drug, and (3) the rate of detoxification Procaine, for instance, is safer than cocaine, largely because it is more rapidly metabolized by the body. The ratio of toxicity of some of the commonly used drugs is as follows:

Procaine	1	Nupercaine	20
Metycaine	3	Cocaine	4
Pontocaine	10	Anesthesin	½

These drugs are not used in the same per cent concentration, so that the corrected toxicity is not the same as that given above. However, procaine is generally considered the safest drug for use in the production of local anesthesia. It is unsafe to use more than 1 gram of procaine for any one procedure. The dosage can be kept within proper limits by using solutions of proper strength; a 2 per cent solution of procaine is necessary only for penetration of large nerve trunks, such as those involved in a brachial plexus or caudal block; for almost all other blocks, a 1 per cent solution suffices, and when used for field block or local infiltration, a ½ or ¼ per cent solution is adequate In elderly or debilitated individuals and in children, the concentration and dosage of the drug should be decreased. The rate of absorp-

tion of the drug may be appreciably slowed by adding a vasoconstrictor substance, usually Adrenalin. When Adrenalin (epinephrine) is used, it is added in amount sufficient to give a concentration of that substance of not more than 1 part in 200,000 parts of the solution. This strength gives adequate vasoconstriction, and the use of a larger quantity of Adrenalin may give a disagreeable reaction. Incidentally, the local anesthetic agent is frequently blamed for such reactions. The addition of a vasoconstrictor substance not only slows absorption but also prolongs the period of anesthesia. During the induction of local anesthesia, special care must be taken to avoid the intravascular injection of the drug; for the introduction of as little as 100 mg of procaine into the blood stream may result in convulsions. In caudal or other epidural blocks and in paravertebral or cervical blocks, it is possible to deposit the drug in the subarachnoid space, especially since this space may extend along the nerve sheaths for an appreciable distance outside the vertebral canal

A barbiturate with moderately prolonged action, Nembutal for example, should be given an hour before injection of the local anesthetic is begun. This usually prevents a reaction from the anesthetic drug.

Treatment of Complications

Patients who are being operated upon under local anesthesia should be carefully watched for evidence of reaction. Most reactions can be successfully handled, but only if the necessary items of equipment are immediately available. The most important of these is a rapid-acting soluble barbiturate of which Pentothal is the most satisfactory, since it acts and is eliminated most rapidly If, when the first symptoms are observed, a small amount is given intravenously, one can prevent further development of the reaction If convulsions do occur, a few cubic centimeters of Pentothal will control them Oxygen should also be given, but it is useless to attempt to do this until the convulsions have been controlled. Following major reactions the blood pressure falls, but this may be corrected by the prompt administration of fluids by vein. Unless these simple agents are immediately available, the time taken to assemble and prepare them will likely result in the death of the patient should a major reaction occur.

CURARE

Curare may be used supplementary to certain anesthetic agents such as Pentothal to give muscle relaxation. It is also used to supplement small amounts of such anesthetic agents as ether and cyclopropane. Adequate relaxation may thus be obtained without exposing the patient to the deleterious and disagreeable effects which so often follow the use of larger quantities of these agents. Curare is a potent drug and must not be employed by individuals inadequately trained in anesthesia. In this connection it is well to remember that curare originally was used to kill animals by placing a small amount of it on the tip of an arrow. Standardization and purification have not removed the action which made this possible.

Nervous System

While the exact mode of action of curare on the central nervous system has not been determined, it is obvious that it plays no part in narcotizing the patient. It acts peripherally as an autonomic blocking agent and it is thought that the fall

in blood pressure that occasionally occurs following the use of curare is due to blocking of the sympathetic ganglia It has been suggested that curare be used to block carotid sinus, vagal and celiac ganglion reflexes.

Cardiovascular System

Curare has no direct action on the myocardium The fall in blood pressure which sometimes occurs during the use of curare is thought to be caused by the following factors· blocking of the sympathetic ganglia, relaxation of the skeletal musculature with loss of support for the vascular bed, and the release of histamine. The release of histamine has been demonstrated following the administration of curare

Respiratory System

Weakness, even complete paralysis of the muscles of respiration, occurs as a result of the peripheral action of curare. In the dosage used in connection with anesthesia, curare has no effect on the respiratory center, but when used in amounts sufficient to give adequate relaxation, it inevitably causes a decreased respiratory exchange. Bronchospasm, which occasionally occurs during light anesthesia, is most likely caused by the release of histamine through the action of curare.

Muscular Relaxation

Curare produces muscular relaxation by blocking the nervous impulse at the neuromuscular junction. The small muscles of the head and neck are first affected, then, with increase in dosage, the muscles of the trunk and extremities are involved. The diaphragm fortunately is the last muscle affected.

Curare produces no significant effects on patients other than those described and is suitable for use in supplementing anesthesia in poor-risk patients It does not enter the fetal circulation and therefore may be safely used in connection with obstetrical anesthesia. It has no effect on smooth muscle.

Myasthenia gravis, obstruction of the respiratory tract, and inability to gain control of the patient's respirations by intubation are contraindications to the use of curare.

Technic of Administration

The average initial dose of curare is about 2 c.c , which contains 6 mg. or 40 units of d-tubocurarine. This amount of the drug, administered intravenously, after light general anesthesia is attained, may give adequate muscle relaxation, but the dosage must vary with the individual patient. The effect is noted within about two minutes, and within three or four minutes maximal relaxation will have occurred. Subsequent doses of 0 5 to 1 c.c. can be given to secure and maintain the desired relaxation There is always some degree of respiratory depression, but this usually disappears within approximately ten minutes, while muscular relaxation ordinarily lasts for twenty to thirty minutes. Since there is some cumulative effect with curare, subsequent doses should not be as large as the original dose Because patients under the influence of curare are unable to make adequate respiratory excursions, they must have respiratory assistance from the anesthetist Also, an endotracheal tube is usually necessary and if not inserted must be immediately available. The difficulties reported in connection with the use of curare are probably due to inadequate

respiratory exchange, causing anoxia and retention of carbon dioxide. Prolonged partial asphyxia may produce irreversible changes in the respiratory mechanism. Inadequate respiratory excursions also may result in atelectasis of portions of the lung. As mentioned previously, the absence of cyanosis does not necessarily mean there is adequate respiratory exchange.

Antidotes

It is imperative to administer oxygen by mask or preferably through an endotracheal tube along with manual compression of the rebreathing bag until the patient resumes normal respirations. Prostigmin is pharmacologically antagonistic to curare and may be of some benefit when given in 1 or 2 c.c. doses. Atropine should be given with the Prostigmin.

INTRAVENOUS PROCAINE

Procaine, administered intravenously, has been used for general anesthesia and sometimes to supplement other anesthetic agents, but it is most useful for the relief of severe pain and in the treatment of certain allergic manifestations. The indications for the intravenous administration of procaine still are not well defined. It was first used to relieve the intense itching often associated with jaundice. Procaine frequently is given intravenously to correct cardiac arrhythmias, particularly those which develop during intrathoracic operations. It is also used as a prophylactic measure to prevent cardiac arrhythmias from occurring in the course of certain surgical procedures, especially those performed near the heart. Pharmacologically, procaine apparently acts as an antagonist of acetylcholine, producing a depressant effect at the myoneural junction. Also it is thought that it may potentiate the action of Adrenalin when used in the treatment of serum sickness.

Method of Administration

The patient should be given a barbiturate an hour before the intravenous administration of procaine. For therapeutic purposes, procaine is given intravenously in 0.1 or 0 2 per cent solutions mixed with normal saline or dextrose solution. The mixture should be given very slowly for the first ten or fifteen minutes, and the patient should be carefully observed for the possibility of an adverse procaine reaction. The initial manifestations of a procaine reaction are: cerebral stimulation with nervousness, apprehension, pallor, sweating, and irregular respirations, followed by depression and collapse. Convulsions may occur during the period of stimulation. Allergic reactions with an asthmatic type of breathing also are said to occur. Rapid acting barbiturates such as Pentothal are antidotes for procaine and should be available for immediate use. Oxygen also should be immediately available and should be given. If asthma develops, Adrenalin should be given for its relief. After it has been determined that the patient has no undue sensitivity to procaine, the rate of injection may be speeded up so that the administration is completed within an hour Four milligrams of procaine per kilogram of body weight, every twenty minutes, appear to be the optimum dose. A convenient method is to mix 1 gram of procaine in 0.1 or 0.2 per cent solution, giving the entire amount to the patient at the recommended rate, if necessary for relief.

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CHOICE OF ANESTHESIA FOR SPECIFIC OPERATIONS

Anesthesia in Thoracic Surgery

The majority of anesthetic agents and many anesthesia technics have been used for thoracic operations. For operations upon the thoracic wall, including thoracoplasties, various forms of local anesthesia or combinations of local anesthesia with light general anesthesia may be employed, but if there is any likelihood of interference with respiratory function during such operations, general anesthesia should be administered, using the endotracheal technic. Patients who are to have thoracic operations often have impaired respiratory physiology, making it especially important that means for providing adequate ventilation be immediately available. Even in patients with essentially normal pulmonary function, wide opening of the chest causes reduction in lung volume, paradoxical motion, and interference with the flow of blood to the heart. Ventilation and oxygenation are thereby seriously impaired.

With the pleura open, the exposed lung collapses, and the mediastinum shifts toward the opposite side, partially collapsing the opposite lung. This sudden deflation of the lungs reflexly produces more vigorous respiratory efforts, and if the mediastinum is normally mobile, these exaggerated respiratory efforts result in so-called mediastinal flutter with paradoxical respirations. In paradoxical respiration, during expiration, a portion of the air passes from the protected lung to the exposed lung, then is drawn back into the protected lung during inspiration. This leads to anoxemia and retention of carbon dioxide. The anoxemia stimulates the carotid body, and the accumulation of carbon dioxide stimulates the respiratory center in the medulla. With an intratracheal tube in place, one can readily prevent pulmonary collapse and paradoxical movement by raising the intrabronchial pressure to, or a little above, atmospheric pressure. A mixture of an anesthetic gas with a high concentration of oxygen may be used to distend the lung, thus preventing anoxia and avoiding the reflex stimulation which results from pulmonary collapse. When ventilation is inadequate, the administration of oxygen will prevent cyanosis, but carbon dioxide will not be properly eliminated and this will result in a reduction of the alkali reserve. By assisting respiration, excess carbon dioxide may be eliminated. An intratracheal tube permits frequent aspiration of the tracheobronchial tree, which is important in all thoracic operations, and altogether necessary in operations for pulmonary abscess, pulmonary tuberculosis, and bronchiectasis. The evacuation of pus frequently is a major problem during thoracic operations. Preoperative postural drainage is of some benefit, but it is essential that purulent secretions be aspirated frequently, so the patient should be placed in such a position on the operating table as to facilitate drainage into the trachea where the suction tube can pick it up.

Cardiac arrhythmias often occur during intrathoracic operations, especially when the hilum of the lung is manipulated. Bradycardia with a normal rhythm also may develop under such circumstances The intravenous administration of atropine usually will correct the bradycardia, and the intravenous administration of 100 mg of procaine is recommended for the correction of the cardiac arrhythmias

Ether is probably used more than any other agent for thoracic anesthesia and is generally satisfactory. However, it tends to cause an increase in the rate and

depth of the respirations, and this may be undesirable in some cases. Cyclopropane given with ether promotes quiet respirations and should be used under certain circumstances.

Anesthesia in Patients With Heart Disease

Before operation, patients with symptoms or signs suggesting heart disease should undergo complete studies, including a careful and complete physical examination, x-ray and fluoroscopic examinations, and electrocardiograms. These studies are important and may reveal significant findings, but the functional capacity of the heart, or the cardiac reserve, is of the greatest importance. For this reason a carefully taken history is essential, for from the history and from certain exercise tolerance tests one obtains the most reliable evidence regarding the cardiac reserve. Heart murmurs and certain abnormalities revealed by laboratory studies often are of no special importance in connection with the administration of anesthesia, but the functional capacity of the heart is always of the greatest importance.

Patients in cardiac failure and those with recent coronary artery occlusion or severe angina pectoris are especially poor risks for any type of general anesthesia and should be submitted to operations requiring such anesthesia only when surgery appears to be absolutely necessary When operation is required on patients in cardiac failure, they should be adequately digitalized preoperatively. Digitalization by the intravenous route may be accomplished so rapidly it rarely is necessary to proceed with surgery before this therapeutic effect has been obtained.

Anoxia in patients with heart disease almost inevitably leads to disaster, so it is essential that such patients be kept well oxygenated during the induction period. The induction should, therefore, be smooth and quiet. Once an adequate level of anesthesia is established, the danger from anoxia is reduced, but an abundant supply of oxygen must be administered continuously. This should be kept in mind when choosing anesthetic agents for patients with heart disease. All of the agents presently used in general anesthesia have some adverse effect on the heart. Cyclopropane produces more significant arrhythmias than other agents, but these may be avoided by using moderate levels of anesthesia and by combining cyclopropane with other agents. Curare used with light cyclopropane anesthesia provides the desired relaxation. The addition of a small amount of ether also promotes relaxation and helps prevent the development of arrhythmias during cyclopropane anesthesia Induction of anesthesia with cyclopropane is not particularly objectionable to the patient, since a high percentage of oxygen may be given continuously and there is a minimal period of excitement. However, in patients with significant arrhythmias, cyclopropane probably should be avoided An ether-oxygen mixture is satisfactory for cardiac patients once anesthesia has been established, but a less objectionable agent should be used for induction. Ether appears to have no significant adverse effect on preexisting arrhythmias Nitrous oxide and ethylene are not effective when used with high concentrations of oxygen and therefore are not suitable for use in cardiac patients except to supplement other anesthetic agents. When cardiac failure already exists, Pentothal may increase the failure, but in other forms of heart disease it apparently is well tolerated. However, high concentrations of oxygen must always be given to cardiac patients along with Pentothal.

Spinal anesthesia rarely should be used in patients with seriously impaired cardiac function, especially those with coronary artery disease, for this type of

anesthesia often causes some circulatory instability, and a good cardiac reserve is necessary to compensate for this. However, spinal anesthesia may be used when only a low level of anesthesia is required, as in operations on the lower genitourinary tract and in leg amputations. In such cases there should be no pronounced changes in blood pressure Spinal anesthesia is recommended by some in patients with cardiac decompensation, but a well-conducted inhalation anesthesia gives better control of the patient.

Local anesthesia may be used to excellent advantage in patients with heart disease when the anatomical location is suitable. Apprehension and stress can be largely avoided by proper preoperative sedation. Occasionally it is advisable to give Nembutal Sodium or a combination of morphine and scopolamine by vein during an operation.

Anesthesia in Diabetes Mellitus

Preliminary to elective operations, patients with diabetes should have their sugar metabolism controlled, and dehydration or acidosis must be corrected. During this preliminary period it is essential that there be an adequate caloric intake. In emergencies, dextrose solution containing insulin is given intravenously.

When feasible, local or spinal anesthesia serve the purpose well, for they do not increase the metabolic imbalance. General anesthesia is not necessarily contraindicated in patients with diabetes, but it is important that the anesthetic agent or agents be chosen with care. Certain of the agents commonly used to induce general anesthesia have little or no adverse effect on sugar metabolism, on the acid-base balance, or on the liver and its glycogen content. Cyclopropane and Pentothal are in this group and may therefore be used in diabetics with only moderate risk. Ether, on the other hand, produces a number of undesirable effects and should be used with great care, especially in individuals who have not had careful preoperative preparation.

Anesthesia in Thyroid Surgery

Preliminary medication is of great importance in patients with hyperthyroidism, for such patients require larger dosage for sedation than do individuals with normal metabolic rates. When local anesthesia is to be used, the sedation should be sufficient to render the patient drowsy and somewhat euphoric. If a thyrotoxic patient arrives in the operating room inadequately sedated for operation under local anesthesia, a soluble, short-acting barbiturate or morphine and scopolamine may be given by vein. Adequate sedation also is a necessary preliminary to general anesthesia in these patients

Goiter patients with tracheal compression present especially difficult problems When such patients are given general anesthesia, the accessory respiratory muscles relax, and complete tracheal obstruction occurs Unless the anesthetist is very expert in intubation, the patient may die of asphyxia. It is wiser, therefore, to apply a topical anesthetic to the throat and larynx, then pass an endotracheal tube preliminary to the administration of the general anesthetic.

Ether is often used for thyroidectomy, but may be undesirable in thyrotoxic patients because it produces considerable depletion of the liver glycogen Cyclo-

propane has no such effect and is consequently a safer anesthetic agent in patients with hyperthyroidism. Pentothal and nitrous oxide, supplemented by small amounts of curare, may provide satisfactory anesthesia, but traction on the trachea is apt to produce laryngospasm, so an intratracheal tube should be placed when this combination is to be employed.

Local infiltration or cervical plexus block, alone or in combination, provide satisfactory anesthesia for thyroid surgery. In patients with hyperthyroidism, the anesthetic solution should contain no Adrenalin. Cobefrine in 1:40,000 or 1:80,000 dilution may be used as a vasoconstrictor.

Anesthesia for Neurosurgical Operations

Local anesthesia is useful in neurosurgery, particularly when combined with adequate sedation. However, positioning the patient so that the anesthetist is unable to insert an intratracheal tube and then supplementing the inadequate local anesthesia with Pentothal is to be condemned.

For intracranial operations, quiet unobstructed respiration is essential. Anoxia causes cerebral congestion, and carbon dioxide retention produces dilation of the pial vessels. Properly administered endotracheal anesthesia obviates these difficulties, but the position of the patient occasionally causes kinking of the endotracheal tube, and this must be guarded against. Plastic endotracheal tubes, or those with embedded wire spirals prevent this difficulty. When patients are to be placed in the prone position as for operations upon the spinal cord, the endotracheal technic should always be used. Endotracheal anesthesia also is suitable for operations for ruptured intervertebral discs, but spinal anesthesia also is satisfactory here. Fifty milligrams of procaine and 10 mg. of Pontocaine will provide sufficiently long anesthesia for most of these cases.

Anesthesia for Cleft Palate and Harelip Operations

For such operations, the following routine is satisfactory: For induction give Vinethene, then switch to ether until the patient is sufficiently relaxed for atraumatic intubation. Following intubation, anesthesia may be maintained by the Ayre technic or with a nonrebreathing valve. Deep anesthesia is not necessary, but a level adequate to assure quiet and even respiration without "bucking" on the endotracheal tube is essential. The head of the operating table should be slightly lowered, and the throat should be packed with moist gauze to insure against blood or mucus entering the trachea. Anesthesia by this technic has significantly reduced the operative mortality in these cases. The insufflation technic is unsatisfactory since it does not assure adequate oxygenation There is always a considerable amount of blood and mucus in the air passages with some degree of obstruction to the airway, which results in inadequate elimination of carbon dioxide. Also the increased respirations cause increased bleeding. Most operators find an oral endotracheal tube less in the way than a nasotracheal tube. The right-angled metal connector should be firmly in the corner of the mouth, well out of the surgeon's way.

Anesthesia for Maxillofacial Surgery

Endotracheal anesthesia, with either orotracheal or nasotracheal tube, is satisfactory for this type of surgery. Pentothal and nitrous oxide are desirable for most

cases because the electrocautery is so frequently employed in this area. Pentothal anesthesia without an intratracheal tube, always dangerous, is especially dangerous for surgery in this area. The collection of blood and mucus in the air passages along with the depressed breathing caused by Pentothal is likely to lead to disaster.

Anesthesia for Orthopedic Surgery

Most orthopedic operations present no special anesthetic problems. Pentothal and nitrous oxide provide adequate anesthesia in the majority, and in those individuals who are difficult to control with a reasonable amount of Pentothal, a more potent agent such as cyclopropane may be used to advantage. Ether and oxygen anesthesia also is satisfactory. Elderly patients who are to have reduction of hip fractures require special consideration. Unless there are contraindications, a small amount of Pentothal supplemented by a 50-50 mixture of nitrous oxide and oxygen usually proves satisfactory.

Anesthesia for Urologic Surgery

Many patients on whom urologic procedures are to be performed are elderly and in an age group where cardiovascular disease is common. Many of them will have some degree of renal dysfunction and this must be taken into account in selecting the anesthetic. In addition, the frequent use of various electrical appliances in urologic surgery eliminates the use of explosive agents.

Spinal anesthesia is especially suitable for many urologic procedures, since only a low level of anesthesia is so often required. A moderate dose of the anesthetic drug and a small volume should be used to insure a low level of anesthesia.

Many patients may be given Pentothal combined with a mixture of equal parts of nitrous oxide and oxygen. Urologists should be aware of the advantages of local infiltration anesthesia combined with regional anesthesia, since so many of their patients are poor operative risks For example, in renal and ureteral lesions, local injection of procaine solution into the wound area, and paravertebral block of the tenth, eleventh, and twelfth thoracic and first lumbar segments provides excellent anesthesia with fewer hazards than either general or spinal anesthesia.

Operations on Patients With Pulmonary Disease

Patients with extensive pulmonary disease are difficult anesthesia problems because of their lowered vital capacity as well as the presence of excessive secretions in the air passages Patients with marked reduction in vital capacity should be given an anesthetic which is effective when combined with a high percentage of oxygen Ether and cyclopropane both meet this requirement, but ether increases bronchial secretions and is often undesirable for this reason. Local infiltration and regional block combined with an inhalation anesthetic often prove satisfactory in such cases When there is a significant degree of emphysema, induction with an inhalation agent is prolonged and so is the time required for reaction. Under such circumstances one may produce a "nitrogen blow-off" by administering a large volume of oxygen By this means oxygen is made to displace a large part of the nitrogen in the pulmonary alveoli and in the body tissues. Oxygen combined with an anesthetic agent now is more readily absorbed.

Operations on Patients in Shock

It is generally agreed that, whenever possible, operation should be deferred until shock has been adequately treated, but shock often cannot be controlled in the presence of continued hemorrhage. Under such circumstances, immediate surgery may give patients their only chance of survival. In these cases the prompt administration of blood or plasma (preferably blood) is essential. Exposure of a vein and insertion of a cannula often is required to establish means of giving adequate amounts of blood at a sufficiently rapid rate. When operation is to be done in an area anatomically suitable, local infiltration and regional block anesthesia should be used Oxygen should be given to such patients in high concentration so as to permit complete saturation of the blood.

If general anesthesia is necessary, cyclopropane appears to be best tolerated. It may be necessary to supplement this with curare or a little ether for relaxation. Experimental and clinical evidence indicates that Pentothal and ether are less well tolerated.

Spinal anesthesia should not be used on patients in shock.

Anesthesia for Operation on Patients With Intestinal Obstruction and Pronounced Distention

In patients with intestinal obstruction, a Levine tube must be used to empty the stomach and the proximal jejunum before anesthesia is begun, otherwise vomiting may occur with aspiration of the vomitus into the air passages. This is especially apt to happen if curare is used, for it relaxes both the diaphragmatic pinchcock and the pharyngeal constrictors and allows the gastric contents to enter the larynx. These are seriously ill patients, so a well-conducted anesthesia is essential. On the other hand, the surgeon faces difficult operative conditions, requiring good relaxation. Endotracheal anesthesia provides the best control for this situation. The anesthetic agent or agents used must be decided upon in each individual case on the basis of the associated circumstances.

Spinal anesthesia frequently is recommended, and in patients with early obstruction it may be the anesthetic of choice. In late obstruction the blood volume is reduced, so the vasodilatation which accompanies spinal anesthesia is apt to produce circulatory collapse. Also the level of spinal anesthesia is difficult to control in these cases. Cases have been reported in which it was thought that rupture of a gangrenous gut resulted from the increased contraction caused by the spinal anesthesia.

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CHAPTER 7

COLLATERAL CIRCULATION; EXPOSURE AND LIGATION OF ARTERIES

I. A. Bigger

One of the chief indications for ligation of major blood vessels in preantiseptic days was secondary hemorrhage following suppuration This indication is infrequent now, so the elaborate operations that were formerly devised for ligation of almost every artery in the body are largely unnecessary However, occlusion of such large arteries as the carotids, subclavians, iliacs, and femorals may be indicated in the treatment of aneurisms, or for the control of hemorrhage, the result of injury, infection, or neoplasm. Certain of these vessels also may be ligated during, or preliminary to, major amputations. The large veins, especially those of the lower half of the body, including the inferior vena cava, are often ligated as a means of preventing pulmonary embolism, after the development of venous thrombosis, or, under certain circumstances, as a prophylactic measure.

There are certain general principles more or less applicable to the occlusion of all large arteries If there is a choice as to the site of ligation, that area should be chosen which promises the greatest chance for the development of an adequate collateral circulation For example, if there is a choice between ligation of the common femoral and external iliac arteries, the latter site is preferable because the inferior epigastric artery is preserved as an important collateral channel. In general, the more central the obstruction of large vessels, the greater the chance for the development of an adequate collateral circulation, but there are numerous exceptions to this rule Such an exception is found in connection with the femoral arteries. The superficial femoral artery has an excellent collateral bed, whereas the common femoral has a poor collateral. To choose the most desirable site for ligation it is necessary that the surgeon know the location and relative importance of the various collateral channels for the large arteries.

The surgeon must also be familiar with the factors which control the development of arterial collaterals and determine whether or not the circulation will be adequate in case of sudden occlusion of an important arterial trunk. Certain of these factors are: the cross section of the collateral bed as compared with the cross section of the main trunk; the diameter of the individual collateral vessels, the elasticity of their walls, and the degree and duration of vasospasm. The blood volume and content and especially the blood pressure are most important and may determine the outcome. As stated by Quiring, the differential in pressure proximal and distal to the site of occlusion is particularly significant, for it is this difference in pressure which largely determines the size of the collateral channels and the

volume of collateral flow. It is obvious, therefore, that the surgeon may have an important part in determining the outcome when important arterial channels are obstructed surgically or otherwise.

In addition to the factors determining whether or not the circulation will prove adequate, one must also consider the effects of ligation, at various sites, on the condition under treatment. In the presence of hemorrhage, not controllable by other measures, ligation of even the largest arteries may be necessary and the vessel must be obstructed at that level which gives the greatest chance for the control of the hemorrhage, even though the collateral circulation may prove inadequate.

Holman recommends ligation of such vessels as the superficial femoral and brachial arteries just distal to a major collateral branch and again just proximal to the next large branch, thus avoiding the expenditure of energy on the expansion of arterial dead space. It has been shown by experimental and clinical work that ligation of the concomitant vein decreases the chance of the development of ischemic gangrene.

When ligation of a large artery is considered advisable, but not imperative, it should be obstructed by some method which will permit prompt reestablishment of its lumen should the anastomotic channels prove inadequate. Halsted's aluminum bands are useful for this purpose for, as shown by Reid and others, they may be removed even after a lapse of four or five days, with an excellent chance of re-establishment of the blood flow. Strips of fascia are also satisfactory for this purpose, but both the metal band and strips of fascia must be applied with care to avoid injury to the intima; otherwise a clot will form.

The exposure of arteries requires a clear knowledge of the anatomy of the site of operation. The incision usually should be made in line with the vessel, centered over the proposed site of ligation. Allowance must be made for disturbance in anatomic relations caused by neoplasms, aneurisms, etc. Careful hemostasis is particularly necessary during the exposure of large arteries, and the manipulations should be gentle, especially when handling the artery or the tissues immediately adjacent to it. A sharp knife and good sharp dissecting scissors are essential. Nerves appear as solid cords and usually are easily distinguished from arteries, but a nerve resting against an artery transmits pulsation, and this may cause temporary confusion. If the structure is grasped gently between the finger and thumb, it can readily be determined whether the pulsation is transmitted or expansile.

The large arteries have well-developed sheaths, and usually the accompanying vein and nerve are enclosed in the sheath with the artery. In exposing a large artery the sheath should be opened at a distance from important branches. The sheath is picked up with thumb forceps, traction is made to separate it from the artery, and it is incised in the long axis of the vessel After a sufficient opening is made in the vascular sheath, a curved aneurism needle is passed around the artery, starting on the side next to the vein In this connection it should be recalled that below the axilla and below the knee each artery is accompanied by two veins. The needle is moved to and fro, to separate the vessel and sheath laterally and posteriorly. The ligature is then passed through the eye of the needle and drawn around the vessel It may occasionally be more convenient to use a small right-angled clamp. One objection to the use of clamps is that the jaws are apt to catch tabs of adjacent tissue. This usually can be prevented by opening and closing the

forceps several times before placing the ligature in its grasp. In a deep wound, however, an aneurism needle is preferable to a clamp.

For large arteries heavy ligatures of silk or other nonabsorbable material should be used. If very large vessels are ligated in continuity, flat ligatures such as tape or strips of fascia are advisable (Fig. 26). All ligature materials have advantages and disadvantages. Fascia lata strips have many advantages but have the serious disadvantage that they usually do not produce permanent occlusion. On the other hand, if permanent occlusion becomes necessary, the vessel may be doubly ligated with heavy silk and divided between the ligatures.

The so-called surgeon's knot should never be used in ligating large vessels because it is impossible to tell how much pressure is being taken up by the friction of the tie and how much is being applied to the vessel. The first tie can be fixed by grasping it with a mosquito clamp while the second tie is being made; a third tie should always be placed in order to make the knot more secure. It is not necessary to rupture the intima, but sufficient pressure must be made by the first tie to occlude the vessel Reid advised compression of large arteries on each side of the site of ligation, so as better to judge the tension necessary to completely occlude the lumen.

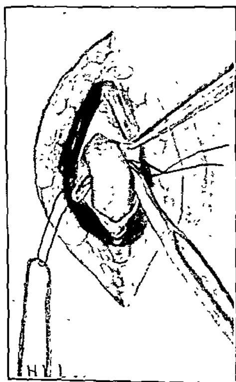


Fig 26.—Method used to pass heavy ligature material, such as fascia, around an artery.

As a rule, it is safer to divide large arteries, applying two ligatures to the central end, one of them a suture ligature. Also in ligating large arteries, sufficient stump must be left distal to the ligatures to keep them from being rolled off. A good rule is to leave the central segment with a stump as long as the diameter of the vessel.

When large vessels are ligated in the presence of gross contamination or active infection, the danger of the ligatures cutting through, with secondary hemorrhage, is greatly increased. Under such circumstances the application of three ligatures,

with division of the artery between the distal ligatures, is very necessary. Heavy nonabsorbable ligatures should be used even though it may be necessary to remove them later. Also as pointed out by Reid, it is safer to leave the divided ends of the vessel projecting into the open wound than to attempt to bury them beneath the adjacent muscle or fascia. The latter procedure simply prevents free drainage and thereby increases the danger

J. S. Horsley, Jr., found in experimental animals that in order to insure permanent occlusion of a large artery it is necessary to divide it between ligatures. When this is done, the ends retract and a considerable portion of the force of the blood column is utilized in the expansion and protrusion of the free end. Also when

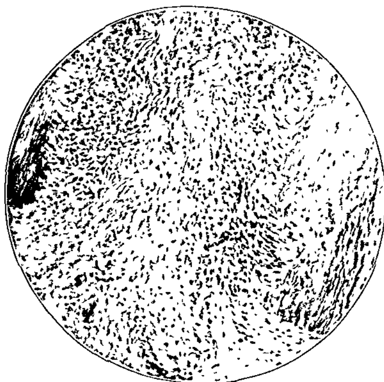


Fig 27.—Longitudinal section through site of double ligatures on femoral artery, 00 plain catgut, forty days after operation This shows distinctly the very narrow transverse band of tissue occluding it, the slight break in the fibrous band probably occurred during preparation of the section, magnification about 17 diameters

an artery is divided between ligatures, the endothelial lining of both ends is exposed to the surrounding tissues, granulation tissue grows in, and both stumps of the vessel are soon healed by a solid cicatricial plug that makes for permanent closure and does not permit re-formation of the channel It was also found that the material used for ligatures was of relatively little importance Eighty ligations of the brachial, femoral, and carotid arteries of dogs with and without division of the artery were studied at intervals of a few hours to seven months after operation. In four of fifty-two ligations in continuity there was partial reestablishment of the



Fig 28 —Longitudinal section of distal ligature of femoral artery after double ligation with 00 plain catgut and division, fifty-eight days after operation; magnification about 17 diameters



al arterial end of
low power photo-
150 diameters

arterial channel, whereas in twenty-eight ligations with division of the vessel there was no instance of reestablishment of the channel (Figs. 27, 28, and 29).

Following the occlusion of a large artery the affected part should not be continuously elevated above the level of the heart. Generally it is safer to place the part at about the cardiac level or even slightly below it, but no position should be used continuously. It is advisable alternately to elevate and depress an extremity in which the arterial blood supply is deficient. When such an extremity is allowed to remain in the dependent position, it becomes edematous, and the edema acts to further decrease the blood supply.

TECHNIC OF EXPOSURE AND LIGATION OF CERTAIN LARGE ARTERIES

Innominate Artery

The innominate artery is sometimes ligated for aneurism. It is the largest branch of the arch of the aorta and is about 5 cm. in length. It has its origin opposite the fourth dorsal vertebra; it runs upward, backward, and to the right, and divides, on a level with the upper border of the right sternoclavicular articulation, into the right common carotid and right subclavian arteries. In front of the innominate artery are the manubrium, the right sternoclavicular joint, the remains of the thymus gland, the left innominate vein, the right inferior thyroid vein, and the superior cardiac branches of the right vagus nerve. Posteriorly are the trachea and the right pleura To the right are the right innominate vein, the right vagus nerve, and the right pleura To the left are the left common carotid artery, the remains of the thymus gland, the left inferior thyroid vein, and the trachea.

Numerous incisions for exposure of the innominate artery have been described, among them the angular incision of Mott, the horizontal limb of which is made along the upper margin of the clavicle, with section of the sternomastoid muscle The oblique limb extends up from the medial end of the horizontal limb along the anterior border of the sternomastoid muscle for about 7.5 cm. The incision gives an adequate exposure of the normal innominate artery, but along with all other *cervical incisions it is unsuited for operations upon that artery when it is involved* by arterial aneurism or by arteriovenous fistula.

In the presence of aneurism or fistula, proximal ligation of the innominate artery by any cervical approach is difficult or even impossible. To cope successfully with innominate aneurism or arteriovenous fistula one must have ready access to the base of the artery, to the entire aneurism or fistulous area, and to the first part of the right carotid and subclavian arteries Under these circumstances a transthoracic or transsternal approach is necessary.

The incision illustrated in Figs 30, 31, and 32, with certain modifications, has been used by the author for a variety of purposes such as the removal of adherent cysts and tumors of the right anterior superior mediastinum, for the extirpation of densely adherent right upper lobes, and for the exposure of aneurisms of the innominate artery The incision is started over the right clavicle 4 or 5 cm. from the sternoclavicular *joint and is carried across to the mid portion of the suprasternal* notch, then is curved downward to the level of the second or third intercostal space and out along that space to the nipple line. In certain pulmonary resections,

it is extended into the axilla. The incision is deepened to expose the upper border of the inner end of the clavicle, the sternum, and the intercostal muscles between the second and third or third and fourth cartilages. The skin, fascia and pectoral muscles are elevated and turned to the right, as shown in Fig. 31. The second or, at times, the third costal cartilage and the anterior portion of the corresponding rib are resected subperiosteally. The internal mammary vessels are divided between ligatures and the pleura is entered through the bed of the second rib and cartilage.

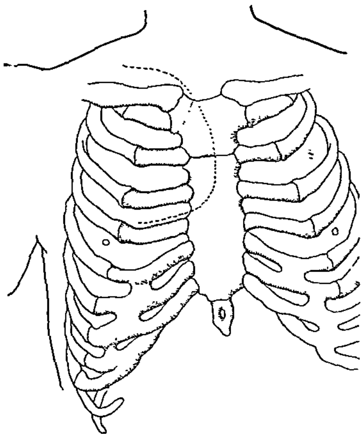


Fig. 30 —Anterior incision for exposure of the upper portion of the mediastinum.

The pleura is incised along with the first intercostal bundle along the sternal border to the junction of the first cartilage with the sternum. The internal mammary vessels are again divided between ligatures and the dissection is extended beneath the sternum and carried upward and to the left to the mid portion of the sternal notch. The communication between the anterior jugular veins is divided between ligatures and the ribbon muscles are separated and retracted to permit the passage of a Gigli saw, which is used to divide the sternum, somewhat as is shown in Fig. 30. It is better to start the section above at the mid portion of the sternal notch, cutting across from there to the first intercostal space. However, the sternum may be sectioned in whatever plane the operator chooses If it seems necessary to have additional exposure to the left, the operator may take a narrow wedge from the right sternal border at the level of the second cartilage, then section the upper sternum in the midline. The pleura of the anterior wall and that overlying the first part of the subclavian artery are stripped to the right, and the upper portion of the mediastinal pleura is stripped downward and posteriorly, care being taken to avoid injury to the right phrenic nerve. By this approach one can gain an excellent exposure of the superior vena cava, the innominate veins, the innominate

artery, and the division of the innominate to form the right subclavian and right carotid arteries. The remnants of the thymus gland and the fatty areolar tissue between the sternum and the aortic arch and its main branches are dissected away, in part or completely, as seems necessary. In innominate aneurisms it is necessary to ligate and divide the right innominate vein near its juncture with the left innominate to form the superior vena cava. This permits retraction of the left innominate vein and the superior cava forward and somewhat to the left for exposure of the origin of the innominate artery from the arch of the aorta. If occlusion of the innominate is deemed necessary, the right cervicodorsal sympathetic ganglia are easily exposed and resected from this approach. Additional room may be gained by dividing the third costal cartilage at the sternum and retracting it downward.

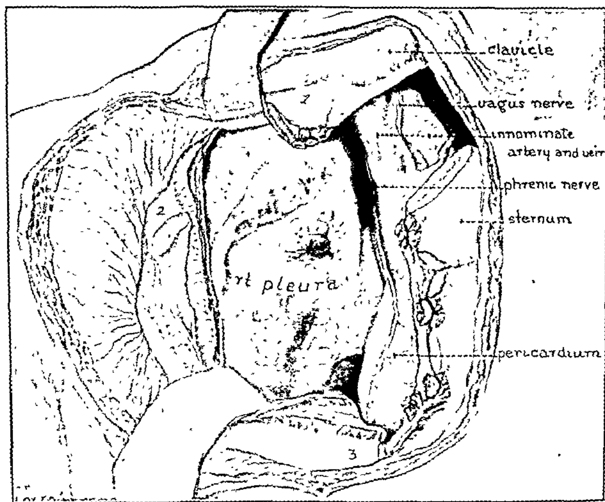


Fig 31.—The pectoral muscles are mobilized and turned laterally with the skin flap The second rib is resected, the upper angle of the sternum is divided by a Gigli saw. An incision is then made in the bed of the second rib, and the clavicle and first rib are retracted upward.

In operations upon the innominate artery, Shumacker makes an angular incision over the inner end of the clavicle, then down the mid-sternum He transsects the sternum at the second or third interspace, then splits the upper segment in the midline. He also resects the inner third of the right clavicle subperiosteally and divides the sternocleidomastoid muscle and the ribbon muscles on that side.

The exposure thus obtained is satisfactory. One of the important advantages of the Shumacker approach to the innominate or subclavian arteries is that it permits preservation of such important collateral channels as the right internal mammary and the upper intercostal arteries. The paired vertebral and thyroid arteries are also important collaterals and should be carefully preserved.

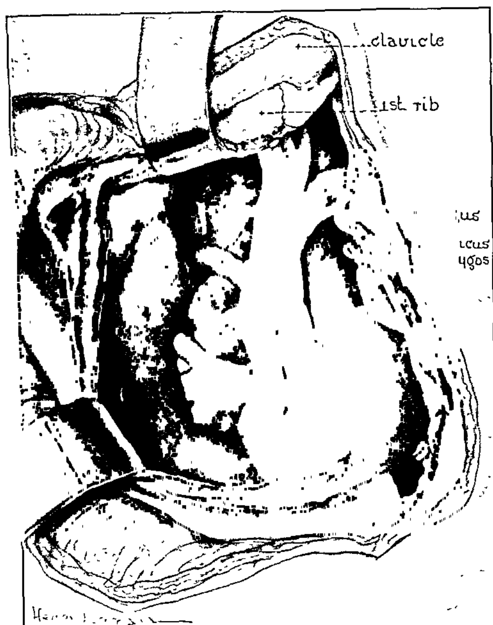


Fig. 32.—Exposure of the mediastinal structures, especially the innominate vessels, by this approach (Pleura omitted so that structures may be better shown)

The Common Carotid Artery

The right common carotid artery arises from the innominate artery and is about 9.5 cm. in length. Its sheath also contains the internal jugular vein, which lies anteriorly and to the lateral side, and the vagus nerve, which lies posterior to and between the artery and vein. The omohyoid muscle crosses the common carotid, and the portion of the artery inferior to this muscle is deeper than that part superior to it.

The left common carotid artery is longer than the right, being about 11 cm. in length. It arises from the middle of the arch of the aorta and courses upward and laterally. It is overlapped by the left lung and pleura in its first portion. The omohyoid muscle crosses on the left side as on the right. The left common carotid has anterior to its thoracic portion the manubrium, the remains of the thymus gland, and the left innominate vein. Behind the thoracic portion of the left common carotid are the trachea, esophagus, thoracic duct, and the left recurrent laryngeal nerve. To the left are the pleura and lung, the left vagus nerve, and the left subclavian artery. To the right are the innominate artery, the trachea, the remains of the thymus gland, and the inferior thyroid vein. In the neck both common carotids have similar relations. Anteriorly are the skin, superficial fascia, deep cervical fascia, the neck muscles that arise from the sternum, the internal jugular vein, the lingual and facial veins, the superior and middle thyroid veins, the descending branch of the hypoglossal and the ansa hypoglossi nerves. Posteriorly are the vagus nerve, the sympathetic nerves, and the cervical branches of the sympathetic to the heart, the recurrent laryngeal nerve, the inferior thyroid artery; the longus colli and the longus capitis muscles, and the transverse processes of the cervical vertebrae. Laterally are the internal jugular vein and the vagus nerve. Medially are the trachea, esophagus, recurrent laryngeal nerve, branches of the inferior thyroid artery, the thyroid gland, the larynx, and the lower part of the pharynx.

The course of the common carotid artery is illustrated by a line drawn from a point just lateral to the sternoclavicular articulation to a point about midway between the angle of the jaw and the tip of the mastoid process. That portion of this line below the upper border of the thyroid cartilage represents the common carotid. Normally there are no branches from the common carotid. If it is to be ligated below the omohyoid muscle, the incision usually is made in the line of the artery from the lower border of the larynx to the sternoclavicular articulation. After cutting through the skin, superficial fascia, and platysma, the superficial veins that are encountered are doubly ligated and divided. The deep fascia is incised along the anterior border of the sternomastoid, which is retracted laterally. The sternohyoid muscle is retracted toward the midline. The anterior thyroid veins are doubly clamped, divided, and tied. The structures which must be protected are the recurrent laryngeal nerve which lies posteromedially, the vagus nerve posterolaterally, and the internal jugular vein anteriorly and laterally.

For ligation of the common carotid above the omohyoid an incision 8 or 9 cm. in length is made along the anterior border of the sternomastoid muscle, centered at the level of the cricoid cartilage. The anterior jugular and facial veins should be recognized, and, as they are large, they are doubly clamped, divided, and ligated The sternomastoid muscle is retracted laterally and the omohyoid muscle is drawn downward and medially. The sheath of the artery is carefully cleared and incised from the medial side to avoid the descending branch of the hypoglossal nerve and the internal jugular vein Ligatures should be passed from the lateral side to protect the internal jugular vein. Generally it is desirable to ligate the internal jugular vein when the common carotid artery is occluded.

For high ligation of the common carotid artery or for ligation of either the internal or external carotids, a somewhat oblique incision along one of the upper cervical creases gives an entirely adequate exposure and heals more satisfactorily,

with less scarring than the conventional incision along the sternomastoid muscle. The oblique incision starts about 3 cm. below and anterior to the mastoid process and is carried downward and forward along the cervical crease to within about 2 or 2.5 cm. of the midline. It is deepened through the subcutaneous tissue and platysma, and the skin, fascia, and platysma flaps are elevated for 3 or 4 cm. above and below the line of incision Care is taken to avoid injury to the great auricular nerve and especially to the inframandibular branch of the facial nerve. In freeing and retracting the sternomastoid muscle, it is well to remember that the spinal accessory nerve penetrates that muscle, though usually at a higher level. The rest of the procedure is carried out as previously described.

The collateral circulation for the carotid arteries is largely through the paired arteries such as the thyroids, inferior and superior, the vertebral arteries by extracranial anastomosis and through the circle of Willis, and through the paired branches of the external carotid artery. The collateral to the extracranial tissues of the head and neck is excellent, and in young individuals the collateral circulation to the brain is good, especially when the common carotid is obstructed. The collateral flow is less adequate when the internal carotid is obstructed because of the partial loss of the collateral bed of the paired branches of the external carotid artery. When it is necessary to obstruct the common carotid and both external and internal carotids, as, for example, in the treatment of aneurism at or near the carotid bifurcation, the collateral flow to the brain is considerably diminished.

Since the common carotid artery has no branches between its origin and its division to form the internal and external carotids, Holman's recommendation in regard to avoidance of long useless main trunk segments should be considered and ligation should be done just below the bifurcation when conditions permit. Additional low ligation would be of no value on the left side, and possibly not of sufficient value to justify it on the right side

Under some circumstances it is desirable to ligate the left common carotid artery within the chest This is readily accomplished by making a transverse incision over the left second rib and cartilage and resecting the cartilage and a rather long segment of the rib The pleura is entered through the rib bed. With the aid of a rib-spreading retractor a satisfactory exposure is obtained, the pleura is incised just to the right of the left subclavian artery and at the upper border of the aortic arch. Special care is exercised to avoid injury to the left vagus and recurrent nerves.

The origin of the right common carotid artery is satisfactorily exposed through a transverse incision in one of the lowest cervical creases, the incision to extend from the external jugular vein, forward and medially to the anteromedial border of the sternocleidomastoid muscle. The superficial structures including the platysma are divided and elevated above and below the line of incision. The sternal and clavicular heads of the sternomastoid muscle are separated and the remainder of the operation is carried out as described above.

External Carotid Artery

The external carotid artery is the smaller of the two terminal divisions of the common carotid and is about 6 cm. in length. It extends distally and slightly posteriorly and terminates in the substance of the parotid gland, where it divides to form the internal maxillary and the superficial temporal arteries.

The important structures superficial to this artery are the anterior border of the sternomastoid muscle, the hypoglossal nerve, the lingual and facial veins, the posterior belly of the digastric muscle, the styloglossus muscle, and, higher up, the branches of the facial nerve and the parotid gland. Posterolaterally are the internal carotid artery, the vagus nerve, and the superior laryngeal nerve. Medially are the hyoid bone and the pharynx, and the deeper part of the parotid gland.



Fig 33.—Ligation of the external carotid artery and the first four of its branches A ligature has also been placed around the common carotid artery The hypoglossal nerve is shown

The external carotid may be ligated either above or below the digastric muscle, the place of election being below that muscle The conventional incision, about 7.5 cm. long, is made just posterior to the anterior border of the sternomastoid muscle and from the level of the middle of the thyroid cartilage to near the level of the angle of the jaw. If the sternomastoid muscle is large, approach to the artery may be made easier by splitting the fibers of this muscle, but ordinarily it is retracted outward. The posterior belly of the digastric muscle is seen at the upper angle of the wound, and then one finds the hypoglossal nerve, crossing the external carotid artery. The thyroid, lingual, and facial veins may be avoided but if too much in the way they may be clamped, divided, and tied. The ligature should be placed below the superior thyroid artery Generally when tying the external carotid preliminary to operations about the oral cavity or face, it is best also to tie the superior thyroid, the lingual and the other accessible branches of the external carotid, as the

collateral circulation is very abundant. Through the same incision, continued slightly upward, the external carotid may be tied above the digastric muscle, though ligation at this level rarely is indicated (Fig. 33).

Internal Carotid Artery

The internal carotid is ligated through an incision similar to that used in ligating the external carotid. The bifurcation of the common carotid is exposed, and the external carotid is identified by its anterior location and by its branches; the internal carotid gives off no branches in the neck. The internal carotid at its origin is slightly posterolateral to the external carotid but it soon occupies a deeper position in the neck. It is tied near its origin. The ligature is passed from the side of the internal jugular vein, care being taken to avoid injury to this vein and also to the vagus nerve, as well as the ascending pharyngeal branch of the external carotid artery.

Both the external and internal carotid arteries are readily exposed by oblique incisions along a cervical crease at about the level of the hyoid bone. The incision is carried through the platysma, which is separated from the underlying structures above and below the line of incision. The inframandibular branch of the facial nerve and the auricular nerve should be protected.

Subclavian Artery

The subclavian artery is preferably ligated in its third portion, but it is sometimes necessary to ligate its first part. Ligation of the first part of the subclavian is somewhat more difficult than ligation of either the second or the third parts, especially on the left side.

The right subclavian artery arises from the innominate artery and is about 7.5 cm in length; the left subclavian is considerably longer since it arises from the arch of the aorta The subclavian arteries are divided into three portions, the first portion extending from their origins to the medial borders of the scalenus anticus muscle. The important structures in front of the first portion of the right subclavian are the sternomastoid, the sternohyoid, and sternothyroid muscles, the right innominate vein, the internal jugular vein, the vagus and phrenic nerves, and the cardiac branches of the sympathetic and of the vagus nerves Behind are the sympathetic nerves, the recurrent laryngeal nerve, the longus colli muscle, the transverse processes of the seventh cervical and the first thoracic vertebrae, the apex of the right lung, the pleura, and the neck of the first rib. Below are the pleura and lung, the recurrent laryngeal nerve, and the subclavian vein. Although the first portion of the left subclavian is longer than on the right, the relations are much the same except that the thoracic duct, the subclavian vein, and the common carotid artery are in front, and the esophagus, the thoracic duct, and the carotid are medial. The second portion of the subclavian artery is from 1.75 to 2.5 cm. long and lies behind the scalenus anticus muscle, which separates the subclavian artery from the subclavian vein Both the first and second portions of the artery are overlapped by the sternomastoid muscle. The phrenic nerve crosses obliquely the lower anterior surface of the scalenus anticus muscle. The trunks of the brachial plexus are located above and lateral to this part of the vessel. The third portion of the subclavian artery lies in the subclavian triangle, whose borders are

the sternomastoid muscle, the posterior belly of the omohyoid muscle, and the upper border of the clavicle. The important structures in front of the third portion of the subclavian are the transverse scapular artery and the external jugular and subclavian veins Behind are the scalenus medius muscle and the lowest trunk of the brachial plexus. Above and laterally are the upper trunks of the brachial plexus, and below is the first rib. As indicated when circumstances permit, the third part of the subclavian is the site for ligation.

Ligation of the first portion of the right subclavian artery can be done by the same angular incision formerly used for exposing the innominate, but, if the artery is essentially normal, this type of incision is unnecessary, and when the vessel is involved by aneurism or arteriovenous fistula, the approach is inadequate and unsatisfactory. In either of these conditions it is essential that the clavicle be resected, otherwise it is almost if not quite impossible to gain complete control of bleeding The inner end of the clavicle is resected subperiosteally by Elkin, Shumacker, and Holman and is best disarticulated from the sternum The clavicle is exposed through a straight incision along its superior border. Elkin and Holman do not replace the bone and simply suture the periosteum Shumacker recommends chipping the resected clavicular segment and filling the periosteum of the clavicle with these chips; he feels that this hastens regeneration. On the left side, the first portion of the subclavian is well exposed transpleurally through the incision recommended for exposure of the left common carotid artery.

The second portion of either subclavian artery, that portion distal to the first group of important branches, may be ligated through a transverse incision starting just above the medial end of the clavicle and extending laterally for 5 to 6 cm The clavicular portion of the sternocleidomastoid muscle is divided and the carotid artery and internal jugular vein are retracted toward the midline The anterior scalenus muscle is exposed and the phrenic nerve and subclavian vein are separated from the anterior surface of this muscle The anterior scalenus is then carefully separated from the trunks of the brachial plexus laterally and the subclavian artery posteriorly The muscle is divided near its attachment to the first rib, and the second portion of the artery is thus exposed. In case of aneurism or arteriovenous fistula, preliminary resection of the medial one-third to one-half of the clavicle is necessary

The third portion of the subclavian artery can be ligated by making an incision just above the clavicle The skin is drawn down and the incision is made over the clavicle, beginning at the posterior border of the sternocleidomastoid muscle and extending laterally and posteriorly for a distance of about 8 or 9 cm. When the skin is relaxed, the incision should be about 1 cm. above the clavicle The margins of the sternocleidomastoid and trapezius muscles are exposed and incised if necessary. The external jugular vein is doubly ligated and divided, as are the veins which empty into it The transverse cervical and the suprascapular arteries usually run near the field but they should be preserved if at all possible as they are important collateral channels The lateral margin of the scalenus anticus muscle, which lies just under the sternomastoid muscle, is identified and followed down to the artery The lowest trunk of the brachial plexus and the subclavian vein, which lies in front of and below the artery are exposed The pleura must be protected The sheath is opened and the ligature is passed from the brachial plexus side, avoiding the pleura and the subclavian vein (Fig 34) When ligating the sub-

clavian artery it may be wise to resect the stellate and upper thoracic sympathetic ganglia to make more certain of an adequate collateral blood supply to the upper extremity. The stellate ganglion lies just posterior to and below the origin of the vertebral artery and is readily exposed after section of the anterior scalenus muscle.

It was formerly felt that the collateral circulation for the first part of the subclavian artery was not especially good, but it has been shown in recent years that the intrathoracic part of the left subclavian and that portion of the right subclavian central to the vertebral and internal mammary arteries can be occluded in children and young adults with little risk of serious ischemia of the corresponding upper extremity. Even in older patients the risk usually is not great. There are many collateral channels, but the more important ones are by way of the paired arteries, such as the vertebral, the internal mammary, and the thyroid arteries, both inferior and superior.

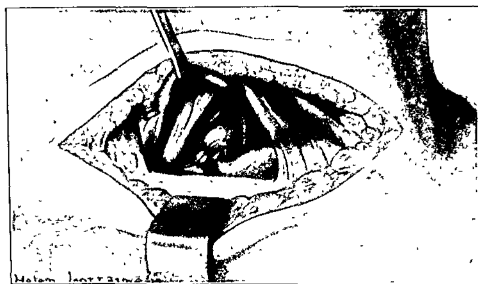


Fig. 34 —Ligation of the third part of the subclavian artery.

The second and third parts of the subclavian artery and the axillary artery have much the same collateral supply, the more important ones centrally being the internal mammary, the branches of the thyrocervical axis, especially the transverse cervical and transverse scapular arteries, which anastomose laterally with the thoraco-acromial, the lateral thoracic, the subscapular, and circumflex scapular arteries. This anastomotic ring around the scapula is very important. Unless there is extensive damage to the collateral vessels, there is no great danger of serious ischemia from obstruction of either of these arteries. However, as stated elsewhere, when an artery of the size of the common or internal carotids, the subclavians, or the axillaries is tied, it is necessary that every precaution be taken to assure an adequate blood supply to the involved area. Careful preservation of all important collateral channels is necessary, and sympathectomy usually is advisable.

Vertebral Artery

The vertebral artery is the largest and usually the first branch of the subclavian and may be exposed by the incision used in ligating the common carotid in its proximal portion or that used for the second portion of the subclavian. By the former route, after exposing the sheath of the common carotid, this vessel, the

internal jugular vein, and the vagus nerve are retracted laterally and the prevertebral fascia is incised vertically below the transverse process of the sixth cervical vertebra. A short distance below this point the vertebral artery is crossed by the inferior thyroid artery which is retracted medially along with the recurrent laryngeal nerve. The vertebral artery is tied just below the transverse process of the sixth cervical, as the artery enters the foramen transversarium in this vertebra.

If the route used for the second part of the subclavian is adopted, the anterior scalenus is divided and the subclavian artery is exposed. It is dissected free proximally to expose the vertebral, which arises from the posterosuperior surface of the subclavian and usually is the first and largest branch given off by that artery. Care should be exercised to avoid injury to the phrenic nerve and to the sympathetic nerves. The latter usually encircle the subclavian near the origin of the vertebral.

Axillary Artery

The axillary artery is a continuation of the subclavian and begins at the outer border of the first rib and ends at the lower border of the tendon of the teres major muscle, where it becomes the brachial artery. The axillary artery is divided into three parts by the tendon of the pectoralis minor muscle, which covers the middle or second part of the artery. The first part of the artery, which extends from the outer border of the first rib to the upper border of the pectoralis minor muscle, has in front the major pectoral muscle, the coracoclavicular fascia, the cephalic vein, and the lateral anterior thoracic nerve. Posteriorly there are no especially important structures. Laterally and medially are the cords of the brachial plexus. Medially, also, is the axillary vein. The second part, which lies behind the pectoralis minor muscle, has posteriorly the posterior cord of the brachial plexus and laterally the lateral cord; while medially are the medial cord of the brachial plexus and the axillary vein. The second part is about 3 cm in length. The third part, which is the longest, about 7 5 cm , extends from the lower border of the pectoralis minor to the lower border of the tendon of the teres major muscle In front are the pectoralis major muscle, the median nerve, the medial antibrachial cutaneous nerve, and the vein. Posteriorly are the radial nerve, the axillary nerve and the thoracodorsal nerve, and the latissimus dorsi, teres major, and subcapularis muscles. Laterally are the lateral segment of the median nerve, the musculocutaneous nerve and the coracobrachialis muscle. Medially are the ulnar nerve, the medial brachial cutaneous nerve, and the axillary vein.

The third part of the axillary artery is the one more often ligated. When ligation of the first part seems indicated, it is as well to tie the third part of the subclavian. Ligation of the first part of the axillary artery can be done by an incision below the clavicle extending from near the lateral portion of the sternoclavicular joint to the coracoid process of the scapula The branches of the thoracoacromial artery should be carefully protected to insure a better collateral circulation The fibers of the major pectoral muscle are separated and the branches of the lateral anterior thoracic nerve with the veins in its neighborhood are retracted laterally The artery here lies between the axillary vein on the medial side and the brachial plexus on the lateral side

If it is necessary to ligate the first part of the axillary artery for aneurism or arteriovenous fistula, it is better to resect or at the least divide the clavicle The

periosteum of the clavicle is separated from it locally and a Gigli saw is then passed under the bone, which is cut squarely across. The clavicle may then be elevated so as to give a much more adequate exposure for ligation of the artery. During closure, a segment of a Steinmann pin may be inserted into the bony canal to stabilize the clavicle

The third part of the axillary artery is ligated through an incision 7.5 cm. long, which begins opposite the anterior part of the apex of the medial wall of the axilla and passes outward and downward along the medial border of the coracobrachialis muscle, the arm, of course, being abducted. The coracobrachialis muscle, the musculocutaneous nerve, and the median nerve are retracted laterally and upward. The medial brachial and antibrachial cutaneous nerves and the ulnar nerve are retracted medially. The axillary vein may be present on the medial side of the artery or the basilic vein may be found here. The ligatures should be passed from the side of the vein.

Brachial Artery

The brachial artery extends from the termination of the axillary artery at the lower border of the tendon of the teres major muscle to about opposite the neck of the radius. The chief relations are, anteriorly, the median nerve; posteriorly, in the upper portion of the artery, the radial nerve, then the profunda brachii artery and the medial head of the triceps muscle, the insertion of the coracobrachialis, which slightly overlaps the artery, and the belly of the biceps brachii, which also slightly overlaps the artery Medially are the medial antibrachial cutaneous and ulnar nerves in the proximal portion of the arm. The basilic vein or one of the venae comites are also on the medial side of the artery.

The middle of the arm has generally been considered the site of election for ligation of the brachial artery. The course of the artery is indicated by a line from the junction of the anterior and middle thirds of the lateral wall of the axilla to the mid-point of the bend of the elbow. An incision about 7.5 cm. long is made, centering at the middle of the arm and extending along the medial border of the biceps muscle in the line of the artery. The belly of the biceps must be recognized and retracted laterally. The median nerve crosses the front of the artery about the middle of this incision and the medial antibrachial cutaneous nerve is on the medial side of the artery.

There is adequate collateral for this portion of the brachial, especially if it is ligated just distal to the superior ulnar collateral artery. Proximally there is the profunda brachii and the superior ulnar collateral, while distally there are the ulnar recurrents, the radial recurrent, and to some extent the inferior ulnar collateral arteries.

LIGATION OF THE ABDOMINAL AORTA

Ligation of the abdominal aorta is always an extremely serious undertaking and probably is unjustifiable except in that segment below the renal and superior mesenteric arteries Thirty years ago George Tully Vaughan gave a résumé of nineteen consecutive cases, all of which terminated fatally. However, one patient, operated upon by W. W. Keen on Dec 12, 1899, lived forty-eight days. In this

patient the ligature was applied just below the diaphragm. Death occurred from hemorrhage, the result of the ligature cutting through.

In a personal case reported by Vaughan, Brasdor's method of distal ligation was adopted; the ligature, a piece of tape, was placed around the aorta below the aneurism just distal to the origin of the inferior mesenteric artery. The aneurism had developed from the left side of the aorta behind the pancreas and about opposite the origin of the superior mesenteric artery. The patient made a satisfactory clinical recovery and died two years and one month after operation. Necropsy showed the aneurism to be considerably larger than at the time of the operation but it had not ruptured. It contained a large firm reddish-white clot and relatively little fluid blood. Death was apparently not due to the aneurism, though the aneurism had not been cured.

In 1925 Rudolph Matas reported, before the American Surgical Association, a case of ligation of the aorta for abdominal aneurism, with the patient surviving the operation for more than a year and dying from a disease unrelated to the aneurism.

In 1926 Brooks reported a case in which he ligated the abdominal aorta for aneurism. The patient was carefully studied before operation and it seemed that a satisfactory collateral circulation had been established. There was no pulsation of the left femoral artery and very feeble pulsation of the right femoral artery. The aneurism was exposed and found to fill the lower abdomen and to extend far out in the left flank. The abdominal aorta proximal to the aneurism appeared normal. An attempt was made to extirpate the aneurismal sac but this was abandoned because an injury to its wall was followed by a terrific hemorrhage. This was controlled by inserting the thumb through the rent in the sac. The aorta was ligated with a strip of fascia lata about 0 5 cm. in width, which was passed twice around the vessel just distal to the origin of the inferior mesenteric artery. This was drawn tightly enough to stop all distal pulsation, and a braided silk ligature was tied around the aorta between this and the aneurism, there being a space of about 1 cm between the two ligatures. The patient developed pneumonia but made a satisfactory recovery. The aneurism became smaller and at no time pulsated, but pulsation reappeared in the left femoral artery. The patient was relieved of pain and returned to work, but about three months later he developed intestinal obstruction from which he died in a few hours. Necropsy showed that the aneurism had shrunken to a firm mass "about the size of a small orange which was firmly fixed to the vertebral column at the site of the promontory of the sacrum." The aneurismal sac was completely obliterated

Ligation of the abdominal aorta below the renal arteries is best done through a left paramedian incision which should be 20 to 25 cm. in length and centered at the umbilicus. The medial border of the rectus muscle is separated from the sheath and retracted laterally Special care should be taken to avoid injury to the superior and deep epigastric arteries, as these are important collateral channels. The posterior sheath of the rectus muscle and the peritoneum are incised, the patient is placed in the Trendelenburg position, and the intestines are packed upward The posterior parietal peritoneum is carefully incised over the left anterior surface of the aorta, care being taken to avoid injury to the branches of the inferior mesenteric artery if the ligation is to be below the origin of this vessel. If the

ligation is to be above the origin of the inferior mesenteric artery, great care must be exercised to avoid injury to the vessels in the root of the mesentery. Careful blunt dissection is necessary to accomplish this

When ligation is done above the inferior mesenteric artery, the third portion of the duodenum is exposed, gently separated from the surrounding tissues, and retracted upward. This brings the aorta into view, but only a limited exposure is possible at this level. If sufficient room can be obtained, it would seem desirable to occlude the aorta, as far proximally as possible, by a heavy strip of fascia lata, which should be passed around the vessel twice before it is fixed by mattress sutures of silk If the vessel is to be permanently occluded, two ligatures of heavy braided silk are placed below the fascial band, and, if the silk ligatures can be placed sufficiently far apart, the vessel wall should be divided between them If the condition of the arterial wall permits, division and suture may be preferable to the use of ligatures Fascia is used to occlude the vessel proximally as it does not tend to cut through the wall of large arteries as do other ligature materials. This same type of procedure should be carried out when the vessel is occluded below the inferior mesenteric artery, and fortunately more room is available at this level unless the aneurism itself interferes with the exposure, as may occur.

As previously stated, it is doubtful whether ligation of the abdominal aorta should be attempted above the level of the superior mesenteric and renal arteries. If occlusion above this level is indicated, it would seem wiser to follow the suggestion made by Halsted and Reid to occlude the lower portion of the thoracic aorta, as it is much less difficult to expose and occlusion at this level gives a better chance for the development of an adequate collateral circulation to the abdominal organs, especially to the kidneys Unless immediate occlusion is imperative, as in ruptured abdominal aneurism, it seems wiser first to partially occlude the lower thoracic aorta, either by fascia or by a metal band, of the type recommended by Halsted, Matas, and Reid. Partial occlusion by a strip of fascia is preferable as the first step of the operation Heavy pieces of braided silk should be left looped around the vessel at proper levels distal to the fascial band for use in drawing ligatures around the vessel at a later stage At the second stage the aorta should be completely occluded by fascia proximally, then divided distally and the ends sutured. If the wall is too sclerotic to hold sutures, it should be divided between heavy braided silk ligatures. Intervening intercostal vessels must be ligated, but all other collaterals should be protected.

We have occluded the abdominal aorta above the inferior mesenteric artery a number of times and in no instance has there been evidence of serious interference with the blood supply to the colon, but it should be noted that these patients had aortic aneurisms which no doubt had resulted in an increased collateral bed. However, these results are in keeping with the experimental work done by Archibald more than forty years ago Archibald showed that in dogs the main stem of the inferior mesenteric artery could be tied with very slight risk of producing ischemic necrosis of the colon. On the other hand, when the aorta is tied at that level there is always serious ischemia of the lower extremities and a considerable percentage will develop ischemic gangrene.

The collateral circulation for the abdominal aorta is, as has been indicated, usually inadequate below the renal arteries and always inadequate above the renal arteries. However, there are numerous collateral channels, the most important ones

for the distal aorta being the internal mammary-deep epigastric anastomosis, the superior hemorrhoidal-internal iliac anastomoses, and the lumbar, iliolumbar, and deep circumflex iliac arteries In the female the ovarian-uterine anastomosis is important, but in the male the anastomosis between the testicular artery and the pudendal is of little moment.

LIGATION OF THE COMMON ILIAC ARTERY

The abdominal aorta bifurcates opposite the lower border of the left side of the fourth lumbar vertebra about 1.5 cm. below and a little to the left of the umbilicus. The common iliac arteries pass downward and outward and bifurcate opposite the upper border of the sacroiliac joint to form the external and internal iliac (hypogastric) arteries. On the right side the common iliac artery, near its termination, is crossed by the ureter and is covered with peritoneum and extraperitoneal fascia Posteriorly are the right common iliac vein, the termination of the left common iliac vein, and the beginning of the inferior vena cava. Still further posteriorly are the psoas major muscle, the obturator nerve, and the iliolumbar vessels. Laterally are the beginning of the vena cava, the end of the right common iliac vein, and the psoas major muscle. The left common iliac artery has near its termination, in front, the ureter and the ovarian vessels in the female, the sigmoid mesocolon, and the superior hemorrhoidal artery. Posteriorly are the lower part of the body of the fourth lumbar vertebra, the fifth lumbar vertebra, and the intervertebral disc, the left common iliac vein, the psoas major muscle, and medially are the left common iliac vein, the hypogastric plexus, and the middle sacral artery.

The right common iliac artery is about 5 cm. in length, while the left common iliac is only 4 cm. long. Formerly, when the danger of sepsis was great, opening the peritoneum was avoided whenever possible. In those days the common iliac arteries were exposed by the extraperitoneal operation of Sir Astley Cooper in order to avoid infecting the peritoneum. Since infection is now a far less serious threat, the common iliac as well as the internal iliac arteries are best exposed transperitoneally, usually through a midline abdominal incision extending from the umbilicus to the pubis. A paramedian or midline incision is preferable to a muscle-splitting incision because of the danger of injury to the deep epigastric artery when the latter is used. The patient is placed in the Trendelenburg position and the intestines are packed out of the pelvis The termination of the abdominal aorta is identified and the origins of the common iliac arteries are exposed The peritoneum is incised over the first part of the common iliac artery and the ligature is passed from the side of the vein. As is done elsewhere when space is available, three ligatures are used, dividing the artery between the distal ligatures A stump of at least 1 cm should be left, beyond the ligatures, on the proximal segment.

LIGATION OF THE INTERNAL ILIAC (HYPOGASTRIC) ARTERY

The internal iliac (hypogastric) arteries are about 3 to 3 5 cm in length and arise from the bifurcation of the common iliacs opposite the upper part of the sacroiliac joints The important relations are, anteriorly, the ureter, posteriorly, the external iliac vein and the lumbosacral trunk, and, medially, the internal iliac vein. The obturator nerve is lateral The hypogastric arteries, which may be ligated

to control bleeding in cancer of the uterus, are exposed by the same incision used for exposure of the common iliacs. The bifurcation of the common iliacs opposite the upper border of the sacroiliac joint, is located and the ureter is identified. On the left side the lower part of the sigmoid colon makes the operation slightly more complicated, for on the right side the peritoneum can be divided directly over the vessel. On the right side an incision about 4 cm long is made through the peritoneum, the ureter is freed up and retracted out of the way, and the bifurcation of the common iliac artery to form the external and internal iliacs is easily demonstrated. The fascia over the internal iliac is incised and the ligatures are passed from the medial side, staying in close contact with the artery to protect the external iliac vein and also to avoid injury to the internal iliac vein which lies posterior and medial to the artery (Fig. 35). On the left side the ligation is carried out in the same manner as on the right, except that the peritoneum lateral to the sigmoid is incised longitudinally, the mesentery is freed, and the bowel is retracted toward the midline. This maneuver is especially important when the mesocolon contains considerable fat.



Fig. 35.—Ligation of the internal iliac artery. According to the work of J. S. Horsley, Jr., it is best to place three ligatures and sever the artery between the distal two ligatures

LIGATION OF THE EXTERNAL ILIAC ARTERY

The external iliac artery is 9 to 10 cm. in length. It arises at the upper border of the sacroiliac joint, runs downward, laterally and forward, and terminates posterior to the mid-point of the inguinal (Poupart's) ligament. The external iliac vein lies to the medial side of the artery below, and medially and posteriorly above.

The genital branch of the genitofemoral nerve lies in front of the artery in its lower third. The distal portion of the external iliac artery is crossed by the spermatic artery and vein and the vas deferens in the male, and by the ovarian artery and vein in the female. Also at this point the deep epigastric artery, a very important collateral branch, arises from the anterior surface of the external iliac and courses forward and medially. Posteriorly are the external iliac vein and the medial border of the psoas major muscle. Laterally is the psoas major muscle.

The external iliac artery can be well exposed by the incision used for the common and internal iliacs, but if ligation is to be done near the inguinal ligament, it can be done more satisfactorily by a muscle-splitting incision or by an extraperitoneal approach through an incision parallel to the inguinal ligament and about 1 cm. above that ligament. When the peritoneum is stripped up, care should be taken to protect the branches of the external iliac artery, especially the deep epigastric, because of its value as a collateral channel. Even though the peritoneum is not opened, the Trendelenburg position is a great help. The sheath of the artery is opened from the lateral side to avoid injury to the vein and care is taken to protect the genital branch of the genitofemoral nerve. The artery is ligated 3 or 4 cm above the inguinal ligament.

The collateral circulation for the common and external iliac arteries is relatively satisfactory, far better than for the terminal aorta.

When one common iliac artery is occluded, the paired branches of the internal iliac arteries, such as the uterines in the female, the pudendals in the male, and the vesicals, take part in the collateral supply to the tissues distal to the obstruction, thereby greatly increasing the likelihood of the development of an adequate blood flow.

The collateral circulation for the external iliac arteries is better than that for the common femoral arteries, for the deep circumflex iliac and the deep epigastric, both important collateral channels, form a part of the collateral bed for the external iliacs.

The collateral bed for the internal iliac (hypogastric) arteries is excellent, so good in the female that only slight risk is incurred when both internal iliacs are ligated. The chief collaterals for the internal iliacs are the superior hemorrhoidal arteries, connecting with the middle and inferior hemorrhoidals, the anastomoses between the gluteal and obturator branches of the internal iliac and the lateral and medial femoral circumflex arteries. The uterine arteries, in the female, and the pudendal arteries in the male act as important collateral channels.

LIGATION OF THE FEMORAL ARTERY

The femoral artery, a continuation of the external iliac, begins immediately behind the inguinal ligament about midway between the anterior-superior spine of the ilium and the symphysis pubis. It passes down the anterior and medial side of the thigh to the junction of the middle and lower thirds of the thigh, where it continues as the popliteal artery. The superficial part lies in the femoral (Scarpa's) triangle, which is bounded laterally by the medial margin of the sartorius muscle and medially by the margin of the adductor longus. Its base is formed by the inguinal ligament. The apex of the femoral triangle is the point at which the medial

margin of the sartorius crosses the adductor longus. The lower third of the femoral artery passes through the adductor (Hunter's) canal, which is an aponeurotic channel extending from the apex of the femoral triangle to the lower part of the adductor magnus muscle.

The common femoral artery, extending from the inguinal ligament to the origin of the profunda femoris, is about 3.75 cm. long. The important structures in front are the lumboinguinal nerve and the superficial circumflex iliac vein. Behind are the psoas and pectineus muscles; laterally is the femoral nerve, and medially the femoral vein. The relations of the femoral artery from the origin of the profunda femoris to the apex of the femoral triangle are, in front, the lumboinguinal nerve and, behind, the femoral vein, the profunda vein, and the profunda artery, in the order named; then the pectineus muscle and the adductor longus muscle. Laterally are the branches of the femoral nerve, the saphenous and the nerve to the vastus medialis. Medially is the femoral vein, which assumes a position posterior to the artery at the apex of the femoral triangle. The third division of the femoral artery is that in the adductor canal, where it is quite deep. Behind are the femoral vein, which becomes slightly lateral in its lower portion, and the vastus medialis and adductor muscles. Laterally is the vastus medialis and medially are the adductor longus above and the adductor magnus below.

The optimum point, for ligation of the superficial femoral artery, is immediately distal to the origin of the profunda femoris artery. The apex of the femoral triangle is about 8.75 cm. below the inguinal ligament and the profunda artery arises about 3.75 cm. below the inguinal ligament. The site for ligation therefore lies a little above the halfway mark between the inguinal ligament and the apex of the femoral triangle. The artery overlies the vein to a considerable degree so care must be exercised in separating the two so that the vein will not be torn. The saphenous nerve lies anterolateral to the artery.

Ligation of the common femoral artery carries a serious risk of ischemic gangrene, so, when ligation of the common femoral is indicated, it is safer to ligate the external iliac if associated circumstances permit it, thus gaining the benefit of the deep epigastric artery as a collateral channel.

The common femoral artery can be exposed by an incision about 7.5 cm. long beginning just above the inguinal ligament and extending down in the line of the artery. The superficial circumflex iliac, superficial epigastric, and superficial external pudendal vessels should be avoided, also the lumboinguinal nerve, which is in front of and a little lateral to the artery The femoral nerve lies farther to the lateral side of the artery and outside its sheath. The ligature is passed from the medial side, avoiding injury to the femoral vein (Fig 36). The common femoral artery may also be readily exposed by an incision parallel to the inguinal ligament and about 1 5 cm below it.

The incision for ligation of the superficial femoral artery is started about 2 cm. below the inguinal ligament directly over the common femoral artery and is directed distally and slightly to the medial side of the thigh along the course of the artery, for about 7.5 cm. The common femoral artery lies superficially, covered only by skin, subcutaneous tissue, and fascia and is exposed by careful sharp dissection. The medial edge of the sartorius is freed and the dissection is extended below the division of the common femoral to expose the proximal 2.5 to 3 cm. of the superficial

femoral artery. The artery is separated from the vein by carefully splitting the common sheath with a sharp knife or small dissecting scissors. At this level, the artery often almost completely overlies the vein. When the artery and vein have been completely separated, three medium, braided silk ligatures are applied, the proximal one within a centimeter of the profunda artery, the distal one approximately 2.5 cm. away, so that the two distal ligatures may be roughly 1.5 cm. apart. Section of the artery midway between the distal ligatures leaves a stump beyond the ligature of about 0.75 cm.; a safe margin In arteries the size of the iliacs or femorals it is a good plan to follow Reid's suggestion, that an assistant compress the artery above and below while the ligatures are being tied.

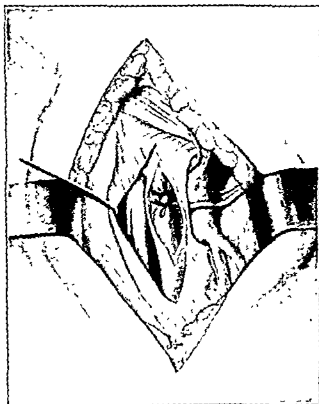


Fig. 36.—Ligation of the right femoral artery just below Poupart's ligament. Three ligatures should be placed and the artery severed between the distal two ligatures.

When it becomes necessary to ligate certain arteries, such as the common iliac, common femoral, or the popliteal, it is usually advisable to ligate the concomitant vein. More important is preliminary interruption of the lumbar sympathetic chain on that side. If the artery is ligated as an emergency, it is wise to block the lumbar sympathetics by injecting procaine solution immediately upon completion of the operation. Should the distal circulation improve following the block but soon show evidence of deterioration, one will do well to proceed promptly with surgical interruption of the lumbar sympathetics. In case of the aorta or common iliac arteries, the sympathectomy may be done through the incision used to expose the artery.

The collateral circulation for the common femoral artery is not especially rich. Two important proximal collateral channels are the deep circumflex iliac and the obturator arteries which form anastomoses with the lateral and medial circumflex femoral arteries Sudden occlusion of the common femoral artery frequently is followed by severe ischemia and not infrequently by ischemic gangrene.

The collateral bed for the superficial femoral artery is good, the main collaterals being the descending iliofemoral circumflex artery and the profunda femoris, by far the most important. As pointed out elsewhere, Holman's principle of ligation just below and just above important collaterals is especially applicable in relation to the superficial femoral artery. Proximal ligation immediately distal to the origin of the profunda femoris and distal ligation above the highest geniculate artery sacrifice only a few small collaterals and a large arterial dead space is avoided.

LIGATION OF THE POPLITEAL ARTERY

The popliteal artery is a continuation of the femoral and extends from the opening in the adductor magnus at the junction of the middle and lower thirds of the thigh downward and laterally through the popliteal space to a point behind the knee joint and then directly downward to the lower border of the popliteus muscle, where it divides to form the anterior and posterior tibial arteries. The important structures in front of the popliteal artery are the posterior surface of the femur, the oblique popliteal ligament, the posterior surface of the upper end of the tibia, and the popliteus muscle. Posteriorly, or superficially, are the medial head of the gastrocnemius muscle, the aponeurotic arch of the soleus muscle, and the popliteal vein, which lies posterior to the artery throughout its course but crosses obliquely from the lateral to the medial side. The vein is in close contact with the artery. The tibial nerve is posterior to the popliteal vein, and is first lateral and posterior, then crosses the popliteal vein and artery and assumes a posterior and medial position in the distal part of the popliteal space.

The artery may be tied either in its proximal or distal portion. It may be approached in its proximal portion from the medial aspect of the thigh or posteriorly from the medial part of the popliteal space. In its distal portion it is exposed through a transverse or an S-shaped incision. A straight incision carried perpendicularly across the crease of the knee leads to contracture and should not be used. For the medial approach to the proximal portion of the artery an incision about 8 or 9 cm. long is made, beginning at the junction of the middle and lower thirds of the thigh and running distally parallel with and immediately posterior to the tendon of the adductor magnus muscle The anterior edge of the sartorius is retracted posteriorly, together with the long saphenous vein, while the tendon of the adductor magnus is identified and drawn forward The artery is found between this tendon and the semimembranosus muscle. The popliteal vein lies superficial to the artery and the tibial nerve is superficial to the vein. Ligation of the popliteal artery is done, preferably in its proximal portion If ligation is necessary in the distal portion of the popliteal space, a transverse incision, made at the level of the flexion crease, is preferable. The skin and fascia are elevated to expose the heads of the gastrocnemius muscle, which are retracted to each side The nerve and vein are retracted medially and the ligature is passed around the artery from that side. If possible, the popliteal artery should be occluded above the inferior geniculate arteries. Ligation of the popliteal vein is advisable when the popliteal artery is occluded

The collateral supply for the popliteal artery is not always adequate, as so often is the case where there is only a small muscle mass surrounding an artery. The descending branch of the lateral femoral circumflex artery, the highest geniculate,

and the lateral and medial superior geniculates are important proximal collateral vessels, while the lateral and medial inferior geniculates and the anterior tibial recurrent are the chief distal collaterals. The greatest care should therefore be exercised to protect these collateral vessels during exposure of the popliteal artery.

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CHAPTER 8

BLOOD VESSEL SUTURE; ARTERIAL EMBOLECTOMY

I. A. Bigger

BLOOD VESSEL SUTURE

At the time of the publication of the fifth edition of this book, only a little more than a decade ago, blood vessel suture was an infrequent undertaking in most hospitals. The situation now is altogether different, for in a number of hospitals blood vessel suture is of daily occurrence and in the majority of hospitals it is performed often enough to be considered a more or less routine procedure. A number of factors were responsible for this development. The large number of vascular injuries encountered in modern warfare has played a considerable part, but the operations developed by Gross, Blalock, Crafoord, and Potts for cure or relief of anomalies of the heart and the great vessels at the base of the heart probably have been an even more important stimulus. At any rate, the suturing of blood vessels is now so frequently done that every surgeon should be familiar with the technic. Actually there is nothing unusual or mysterious about the technic of blood vessel suture; the instruments and sutures are somewhat more delicate and gentleness is perhaps even more essential in vascular surgery than elsewhere. However, the principles involved are the same—minimal trauma to tissue, complete hemostasis, careful asepsis. Since operation upon blood vessels and operations performed under local anesthesia exact gentleness of the surgeon, it might be well to require trainees in surgery to demonstrate a certain degree of proficiency in both these fields before qualifying them as safe and sound surgeons. In the one instance, adverse reaction to roughness is shown by the tissues, in the other by the patient. The only special instruments required for arterial suture are small tissue forceps, small hemostats (so-called mosquito clamps), small and efficient needle holders, and especially constructed clamps for control of bleeding. There are now a considerable number and variety of such clamps available, the majority of them designed and constructed for a specific purpose. The more important ones are the Potts-Smith clamp for lateral anastomosis of the aorta and pulmonary artery, the Blalock clamp for end-to-side anastomoses, and the Potts toothed clamps for division of the patent ductus and for anastomosis of the aorta in the cure of coarctation. This latter clamp is a most ingenious instrument and may be used to advantage in a number of situations other than those for which it was devised. One also needs a few simple spring clamps or bulldog clamps for temporary obstruction of blood vessels. The sutures should be fine and of nonabsorbable material, preferably silk. Under most circumstances sutures of four 0 to six 0 silk swaged on fine needles are satisfactory. Both straight and

curved needles should be available. Many surgeons prefer having the sutures treated with sterile mineral oil or petrolatum before they are used. This probably is of no great importance except that it decreases the drag or resistance of the suture and thus makes it somewhat easier to snug up when a continuous suture is being inserted, as, for example, in the Blalock operation of end-to-side anastomosis of a systemic artery with a pulmonary artery.

There are a number of technics for suturing blood vessels, all more or less satisfactory. On theoretical grounds, interrupted, everting, mattress sutures should be better for end-to-end suture, especially in operations upon children, for it would seem they would be less likely to interfere with enlargement or growth of the anastomotic ring. In practice this appears to be of little importance. Generally speaking, continuous sutures are more satisfactory for they require less time, give more accurate coaptation and, therefore, more complete hemostasis. Carrel used the continuous over-and-over suture (Figs. 37 and 38) with remarkable success, and a good

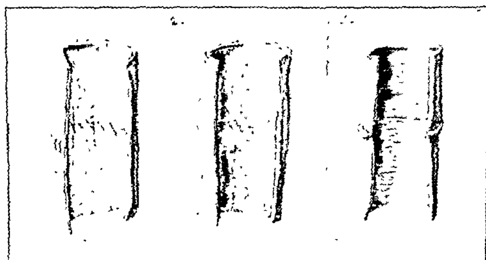


Fig. 37. Fig 38 Fig 39

Fig. 37 —This drawing, reproduced from Guthrie, shows the lumen of a blood vessel immediately after it has been sutured by the method of Carrel Note the large amount of thread exposed in the lumen.

Fig 38 —This drawing, also from Guthrie, shows the lumen of a blood vessel several weeks after successful suture The stitches have been covered by endothelium, which is still transparent

Fig. 39 —This drawing shows the eversion produced by the double mattress stitch and the consequent absence of any raw surfaces in the lumen of the vessel

many surgeons prefer that technic. Crafoord uses a continuous over-and-over suture, which does not penetrate the intima, and feels that, when accurately placed, it gives anatomic approximation of the various layers of the vessel wall. Gross, Blalock, and many others prefer a continuous, everting mattress suture because it approximates intima to intima, exposes less suture material to the blood stream, and does not narrow the lumen at the anastomotic site (Fig. 39) J Shelton Horsley preferred the latter technic for the same reasons. All told, it does seem to have certain advantages over the other methods of suture and it is reasonably certain that one not especially expert in vascular surgery will obtain more satisfactory results by this technic. In arterial anastomosis the superficial portion of the adventitia must be removed from the ends of the artery, and, when large arteries are involved, the

loose part of the adventitia should be removed from the area to be occupied by the obstructing clamps; otherwise, the vessel tends to slip from their grasp.

In addition to the procedures mentioned, vascular suture is indicated in wounds of arteries, especially those made by cutting instruments. More extensive wounds of important arteries, such as the carotids, iliacs, common femorals, etc., not amenable to direct suture may be treated by excision of the devitalized segment and end-to-end suture, or when this is not possible by the use of vein grafts. Arterial embolectomy is another rather frequent indication for suture. Arterial suture is often of value in the cure of traumatic arterial aneurisms and arteriovenous fistulas.

End-to-end arteriovenous anastomosis with reversal of the circulation was formerly thought to be of value in the prevention of ischemic gangrene in certain obstructive lesions of the main arteries, especially those of the lower extremities. It now appears that any improvement which may have been noted following this procedure was due to occurrences incidental to the operation and not to the passage of arterial blood through the veins. The resultant obstruction of the concomitant veins may well have brought some improvement in certain instances. With the failure to improve the blood supply to the extremities by arteriovenous anastomosis in mind, the recent work by Beck and his associates directed toward increasing the blood supply to the central nervous system and to the myocardium by such means is especially interesting. It appears, however, that the anatomic peculiarities of the cardiac venous system may increase the chance of success

Blakemore and his associates have developed an ingenious nonsuture method of blood vessel anastomosis which serves an excellent purpose. The method is simple, easy of accomplishment, and can be performed in a short time.

The technic is briefly as follows: the ends of the artery to be anastomosed are dissected free for a short distance and the adventitia is dissected away in much the same manner as for suture. A suitable vein (possibly the concomitant vein) is freed up and a section of sufficient length is resected The ends of the venous segment are then passed through Vitallium cannulae and turned back to form a collar over the ends of the cannulae, thus giving an endothelium-lined tube and endothelial covering of each end. The endothelium-covered ends of the cannulae are then inserted into the ends of the artery and the artery is fixed to the cannula by silk ligatures, which are prevented from slipping by ridges or shoulders on the cannulae. When the anastomosis is complete, the entire vascular channel is lined by endothelium with no foreign material presenting in the lumen. The objection to the method is, of course, the use of so large an amount of foreign material. However, it is possible to bridge arterial defects by this method under circumstances in which suture would be difficult or impossible

ARTERIAL EMBOLECTOMY

Peripheral arterial embolization is, as a rule, the result of clot formation in the left side of the heart. Mural thrombi may form over an infarcted area, but in a large proportion of cases peripheral emboli develop in patients with auricular fibrillation, usually, though not necessarily, of long standing. Furthermore the auricular appendage is the site of such clot formation. With these facts in mind, Madden, Longmire, and a number of other surgeons have resected the left auricular appendage in patients with auricular fibrillation who had thrown one or more ar-

terial emboli. Also in at least one instance the right auricular appendage has been resected in a patient throwing pulmonary emboli. The results have been encouraging, but the number of such operations so far reported is too small to justify conclusions relative to the value of the procedure.

Emboli thrown into the circulation lodge at main arterial bifurcations or at the site of origin of large branches, such as the profunda brachii, the bifurcation of the aorta, or the origin of the deep femoral artery. They are diagnosed more frequently and probably actually lodge more frequently in the arteries supplying the lower extremities. It is said that approximately 50 per cent of all peripheral emboli lodge at the origin of the deep femoral artery. However, it should be remembered that they may lodge in any part of the body. Embolism to the superior mesenteric artery is not rare, and while I know of no attempt to remove an embolus from that artery, I can see no reason why such an undertaking might not be successful. The difficulty, of course, lies in making the diagnosis early enough.

Embolectomy is the treatment of choice when important arteries of either the upper or lower extremities are blocked. However, satisfactory results are obtained only when the operation is performed early, the earlier the better. Embolectomy within the first six to eight hours gives an excellent chance for complete restoration of the circulation. Under twelve to fifteen hours there are fair chances of success, but when twenty-four or more hours have passed, the outlook is poor. There are a number of reasons why the results become less satisfactory as the time interval increases between lodgment of the embolus and its removal. The intima is progressively damaged by prolonged contact with the embolus, and secondary thrombosis becomes increasingly likely. The extent of collateral obstruction increases because of the formation of clot adjacent to the embolus, and finally the tissues distal to the obstruction including the lining of the vessels suffer increasingly from anoxia, so that extensive thrombus formation occurs distal to the embolus. At this stage, treatment obviously will be of no avail.

There are also a number of reasons for the high incidence of gangrene following the embolic obstruction of major arteries First and possibly most important is the fact that when an embolus lodges at the origin of a large branch or division of an artery such as the deep femoral, it usually occludes the large division as well as the main trunk, thereby blocking a large proportion of the collaterals. Also the sudden blockage seems to cause spasm of the collateral vessels This spasm may be relieved by interrupting the sympathetic nerves supplying that area

Sympathetic interruption may be accomplished by surgery or by procaine block; the latter method should be tried first. If the result is but transient, surgical resection of the sympathetic ganglia is advisable, especially when embolectomy is not feasible or has proved unsatisfactory. Even when embolectomy seems satisfactory, sympathetic procaine blocks should be continued until vasospasm is relieved.

When a patient with embolic obstruction of a major artery is seen within the early hours after lodgment of the embolus, embolectomy should be undertaken without delay unless there are very important contraindications to surgery. Also, the larger the artery obstructed, the greater the necessity for immediate action For example, in true saddle embolus at the bifurcation of the aorta, with obstruction of both iliac arteries, the prognosis is extremely poor unless the embolus is removed promptly. There are now a considerable number of successful aortic embolectomies

in the literature, and with the current improvements in anesthesia, etc., a high percentage of such patients should be saved by early operation.

Approach to the aorta may be extraperitoneal or transperitoneal. The decision as to the route should be made on the basis of the existing circumstances, special consideration being given the patient's general condition and ability to withstand surgery. If the patient's condition seems satisfactory, the transperitoneal approach is better. The aorta and both iliac arteries are more readily exposed, and after the embolus has been removed, one can with almost no additional trauma examine the bifurcation of both common iliacs for other emboli. This is of some importance, for multiple emboli not infrequently occur, and there is also a chance that a fragment will break away from the main mass and obstruct some distal vessel.

A left paramedian incision centering at the umbilicus is suitable for the transperitoneal approach. For the extraperitoneal approach one may use a left transverse incision at the level of the umbilicus, starting 2 to 3 cm. medial to the lateral border of the rectus muscle and extending laterally into the flank for about 12 to 15 cm. When the peritoneum is traversed, the patient is placed in a moderate Trendelenburg position, the small bowel is carefully packed into the upper abdomen, and the posterior peritoneum is incised over the terminal aorta and reflected to expose the terminal aorta and the first few centimeters of the iliac arteries. The terminal aorta is separated from the adjacent structures by careful dissection and a narrow tape is passed around it. Special care must be exercised to avoid injury to the vena cava, which lies just to the right of the aorta. A small section of gauze, rolled into a ball and grasped in a curved clamp, is especially satisfactory for this type of dissection. The common iliac arteries are then freed up and tapes are passed around each of them. The mid-sacral artery should also be occluded. The embolus, which is easily palpable, should be carefully outlined and the incision in the aorta should be centered over it. Should the terminal aorta be sclerotic, the incision may be made in one or the other iliac arteries and the embolus milked out through that opening. When the embolus has been removed, the obstructing tapes should be alternately momentarily relaxed to flush out any remaining fragments of clot. This may be unnecessary if the clot is smooth and symmetrical One tape is relaxed, say on the aorta, while the other two are kept tightened. Then the one that has been relaxed is tightened and another is relaxed. After it is certain there is no further clot present, the incision is closed by a continuous everting mattress suture of four 0 silk on an atraumatic needle The aortic tape is then relaxed and, if there is no bleeding, the tapes are removed. Should there be appreciable seepage, a few interrupted sutures are placed to control it. The peritoneum is carefully closed over the area of the vascular incision. The iliac arteries are now examined to be certain there are no other sites of obstruction It is wise to have an assistant expose the feet and legs at this time. If they are still cold and pale, and the pulse thready (in the presence of a satisfactory blood pressure and pulse in the upper extremities), it may be wise to interrupt rapidly both lumbar sympathetic chains. The abdomen is closed in the usual way Embolectomy should always be performed by a direct approach when possible. For example, attempts at removal of clots from the aortic bifurcation by passing especially designed probes or suction tubes up from the common femoral or external iliac arteries is unwarranted unless the patient's general condition is such that a direct approach would be extremely hazardous.

The removal of emboli from superficially placed vessels such as the brachial and the common femoral arteries is easily accomplished under local infiltration with procaine solution. *The technic is essentially that described for aortic embolectomy.* The approach to the various vessels is described in the section on exposure and ligation of arteries.

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CHAPTER 9

ANEURISMS

LIGATION FOR ANEURISMS; ANEURISMORRHAPHY; ANEURISMECTOMY; VEIN IMPLANTS

I. A. Bigger

An aneurism is a pulsating sac communicating with the lumen of an artery. Aneurisms are divided into two general classes, true and false. A false aneurism is formed from a hematoma and is equivalent to the later stages of the so-called pulsating hematoma. Following injury to an artery, blood is poured out and a hematoma forms. Occasionally a cavity develops in the center of the hematoma in communication with the lumen of the artery and becomes lined with endothelium. The adjacent tissues form a connective tissue sac and there is a typical false aneurism. Aneurisms are not tumors in the ordinarily accepted meaning, for a tumor is new tissue that has sprung from a matrix of cells. A true aneurism is a dilatation of a previously existing vessel and is merely an increase of previously existing tissue.

Surgical operations for aneurism include various methods, such as wiring, electrocoagulation, direct and indirect compression, ligation, incision, obliteration of the sac, and excision of the sac alone or combined with the substitution of a segment of vein.

We shall first consider the methods particularly applicable to aneurisms of the aorta, as these aneurisms often cannot be treated by the surgical measures applicable to aneurisms involving other vessels. "Needling" was advised by Macewen in 1890. The method is uncertain, though Macewen reported satisfactory results. It consists of the introduction into the sac of a long slender needle which scratches thoroughly the lining of the sac This is followed by the deposition of fibrin and, according to Macewen, the fibrin thrown down after needling is peculiarly firm. The operation, however, was never generally adopted

WIRING AND ELECTROTHERMIC COAGULATION

Blakemore has developed a method for wiring and electrothermic coagulation for aortic aneurisms which is complicated and requires a meticulous technic but, when properly executed, yields results superior to those obtained by the technics previously used. Fine, coin silver wire, insulated so that it is capable of withstanding a high-voltage current, is introduced through a needle into the aneurism. When the first ten-meter segment of wire has been inserted, it is connected with a direct current. The segments of wire are heated to 80° C., which causes the deposition of a clot stimulating coagulum upon the wire. On the basis of the number of amperes required to raise the temperature of a ten-meter segment of wire to 80° C., Blakemore is able to determine the amount of wire necessary to produce mass clotting.

This method of electrothermic coagulation is most successfully used in sacculated aneurisms, but Blakemore has used it in somewhat modified form in the arteriosclerotic aneurisms of the distal portion of the abdominal aorta.

LIGATION AND COMPRESSION

Many attempts have been made to cure aneurisms of the abdominal aorta by ligation, but with little success. Proximal ligation alone can hardly be expected to cure aneurisms, although it may give relatively prolonged relief from pain, the result of the compression or erosion of adjacent structures. The difficulty lies in the fact that the maximum effect on the aneurism is obtained only so long as the collateral circulation is relatively inadequate. Once the collateral circulation has become fully reestablished, the pressure within the aneurism sac is restored sufficiently to cause it to enlarge again and to produce symptoms. Even proximal and distal ligation usually will not produce a permanent cure, because the collaterals entering the aneurism sac dilate and lead to recurrence. Ligation should therefore be resorted to only under circumstances which do not permit the performance of curative procedures.

The principle of the gradual occlusion of arteries added greatly to the safety of treatment of aneurisms of certain arteries. It occasionally is employed as a definitive measure, but its chief value is due to the development of the collateral circulation from diminution of the lumen of the main artery. This method of increasing the collateral bed was first recommended by Halsted, who used aluminum bands with smooth edges. These bands were placed around the artery and curled into position by a special device. Later the bands were modified by Matas, who occluded the vessel by flattening the band rather than curling it. Reid adopted the Matas method of applying these metal bands because he believed there was less danger of injury to the wall of the artery. The bands vary in width from 3/16 to 5/16 inch and are about as thick as sheet metal gauge No. 23, or 0.6 mm.

In some interesting experimental work Halsted (1918) found that there frequently was dilatation of the vessel on the distal side of the band which was difficult to explain, but he thought it might be due to an eddy or whorl in the partially obstructed current. The most likely explanation is that the band interferes with the nutrition of the vessel wall, not only that portion under the band but also that immediately distal to it.

In the treatment of aneurisms of the extremities it is important to develop the collateral circulation to as great an extent as possible before an attempt is made to excise the sac or to obliterate it. This may be hastened by the local application of heat in the form of hot packs or, better still, diathermy Proximal compression of the artery by digital pressure or by a special apparatus is also valuable Compression is one of the oldest methods of treating aneurisms and, while various appliances and ingenious methods have been used, they have not been any more satisfactory than digital compression This must be done at first by the surgeon or a well-trained assistant, but if the patient is intelligent and the vessel to be compressed is in a location which he can easily reach, the treatment may soon be turned over to him. The femoral artery below Poupart's ligament and the common carotid artery are among the most favorable locations for digital compression.

Elastic compression has been applied by bandaging the limb with an elastic bandage up to the aneurism and then skipping the aneurism and bandaging the limb above it. In this way the blood was shut off above and below the aneurism and clotting often occurred. However, this procedure proved too dangerous and was discarded.

Extreme flexion also was formerly used in the treatment of aneurisms developing in the popliteal region, in the groin, or in the elbow. It consisted of forced flexion which had to be maintained for a number of days. It was of course exceedingly painful and cured only an occasional case, so it too was discarded. Compression, no matter how applied, is now used only as a means of stimulating the development of the collateral circulation.

The most certain and altogether the most satisfactory way to ensure an adequate collateral circulation is by preliminary section of the sympathetic nerves to the collateral area.

The adequacy of the collateral circulation may be tested preoperatively by the method suggested by Matas. A snug Esmarch bandage is applied from the distal part of the limb to the trunk. The main artery is then compressed, the Esmarch bandage removed, and note is made of the returning circulation which must be carried by collateral channels. In the thigh a hyperemic flush extends quickly to the knee but may go much more slowly or not at all to the foot. If the flush does not reach the ankle, operation should be postponed and treatment continued until a satisfactory collateral bed has been established The value of this test is limited since it is not applicable to the dark-skinned races.

If doubt remains as to the adequacy of the collateral bed, the artery should be exposed proximal to the aneurism and the lumen should be carefully occluded either by a metallic band or by a strip of fascia. In carrying out this procedure it is desirable to leave a very small opening so as to avoid injury to the wall of the vessel, especially to the intima It is usually desirable to tie the vein at the time the artery is occluded. The operation should be carried out under local anesthesia when the carotid artery is involved, otherwise the symptoms and signs of cerebral anemia may be confused with the aftereffects of a general anesthetic, as in a case reported by Reid If evidence of insufficient collateral circulation should develop, the arterial obstruction may be released, with excellent prospects of an immediate satisfactory flow of blood through the main channel. If the collateral circulation proves to be adequate, the surgeon can proceed with the excision or obliteration of the aneurismal sac. The above procedure is especially indicated in aneurisms of the carotid, the common femoral, the popliteal, and the axillary arteries.

Many of the classical methods of using the ligature for the cure of aneurism are now only of historical interest. The operation of Antyllus has been used for the cure of aneurisms since the second century of the Christian Era and still is of some value in selected cases It consists of ligating the artery close to the aneurism, both centrally and distally, and then incising the sac (Fig 40). In preantiseptic days the suppuration following this method gave a high mortality but the percentage of cures was gratifying.

Anel's method, first used in 1710, consists in ligating the artery proximally as close as possible to the sac (Fig. 41). In preantiseptic days when suppuration was the rule, secondary hemorrhage was frequent. It was thought that this was partly due to the fact that the artery near the sac was diseased; so Hunter in 1785 estab-

lished the new principle of applying the ligature at some distance proximal to the aneurism (Fig. 42). In this method important collateral branches are given off from the section of the main artery between the ligature and the aneurism and are therefore unable to function. Hunter's operation is still used occasionally but has many disadvantages, and his assumption that the artery was less diseased at a distance from the aneurism than close to it is by no means always true. The liability to gangrene also is increased, because if the sac is occluded by clot there will be two obstructions to the current instead of one, that at the site of ligature and the other distally at the aneurism sac. The collateral circulation is thereby greatly diminished, for the blood has to pass through two sets of collateral branches, those arising

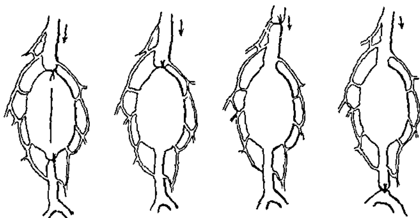


Fig. 40. Fig. 41. Fig. 42. Fig. 43.

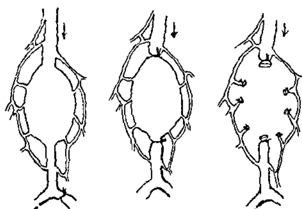


Fig. 44. Fig. 45. Fig. 46.

Fig. 40.—The operation of Antyllus for aneurism
Fig. 41.—The operation of Anel.
Fig. 42.—The operation of John Hunter
Fig. 43.—The operation of Brasdor.
Fig. 44.—The operation of Wardrop.
Fig. 45.—The operation of Pasquin.
Fig. 46.—The operation of Purmann.

proximal to the ligature and those arising distal to the ligature but proximal to the sac. If, on the other hand, the collateral circulation is free, the aneurism may not become filled by clot and no benefit will result. Anel's operation, therefore, is superior to Hunter's except in occasional instances where infection develops in the tissues adjacent to a recently acquired false aneurism. Under such circumstances Hunter's operation may be the procedure of choice.

Brasdor instituted the method of distal ligation in 1798 (Fig. 43), and Wardrop, in 1825, applied ligatures distally to one or two of the main branches of an

artery (Fig. 44). This was used in aneurism of the innominate where the carotid artery was often tied. The application of ligatures immediately above and below the aneurism without opening the sac is called Pasquin's operation, which was first used in 1812 (Fig. 45).

Ligation proximally and distally close to the aneurism with extirpation of the sac has been known as the operation of Purmann, who used it in 1680 (Fig. 46). For this procedure it is necessary to have complete hemostasis, and in the extremities this is best obtained by a tourniquet, because large collateral vessels open into the sac and both central and distal ligatures may fail to control hemorrhage.

In all operations upon aneurisms careful hemostasis is essential, so all vessels of appreciable size immediately in the line of incision must be clamped and ligated as the operation proceeds. On the other hand, important collateral vessels should be carefully protected. After a tourniquet is removed, all bleeding must be controlled with care, for the development of a large hematoma may lead to disaster, either as the result of postoperative infection or the clot may cause sufficient pressure on the surrounding tissues to interfere with the collateral bed. Unless contraindicated, fine silk ligatures should be used, for they produce less tissue reaction and less swelling than ligatures of most other materials.

Proximal and distal ligation with extirpation of the sac is in some respects an ideal method of treatment for aneurisms, but it has a number of serious disadvantages. It is a laborious, time-consuming procedure and may be practically impossible of execution. It also interferes to a greater extent with the collateral circulation than some other methods of treatment. However, excision of the sac, followed by reestablishment of the arterial channel by vein graft, has much to recommend it. So does the use of inlay vein grafts as described by Blakemore.

MATAS OPERATION

One of the great advances in the treatment of aneurisms is the operation of Matas, first performed by him in 1888, on a brachial aneurism that had not been cured by both proximal and distal ligation. The Matas operation may be performed in three ways, though the principle is essentially the same in all three. They are obliterative endoaneurismorrhaphy, restorative endoaneurismorrhaphy, and reconstructive endoaneurismorrhaphy (Figs. 47, 48, and 49). Obliterature endoaneurismorrhaphy (Fig 47) may be used in any form of aneurism, but it was designed particularly for cases in which the two openings in the sac are some distance apart and therefore not suitable for repair, or those in which the sac is particularly friable. Hemostasis is obtained by a tourniquet if possible, or, if this is impracticable, by clamps such as those devised by Crile or Matas, or those devised for lateral suture of blood vessels These clamps are placed on the artery, both above and below the sac, and on its main branches. The sac and adjoining vessel should not be dissected out, so a tourniquet is preferable when one can be used. By bearing in mind the principle on which the operation is founded, conserving every possible collateral branch in the sac and surrounding tissues, the operation can be carried out more effectively. After the tourniquet has been applied, an ample incision is made through the skin over the aneurism. If it is not possible to use a tourniquet, the vessel is exposed proximally and distally near the aneurism and clamps are applied, as mentioned above. The sac is then opened without

separating it from the surrounding structures and the clot is removed. Sutures of adequate size on small, round, full-curved needles are passed through the margins of the openings and tied with care, so that they will not cut through. The sac is then searched for openings of collateral arteries and these are also closed. The circulation is released by removing the tourniquet or clamps to demonstrate

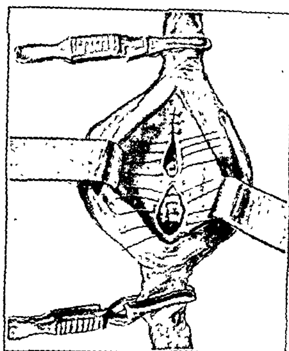


Fig. 47.—Obliterative endoaneurismorrhaphy of Matas

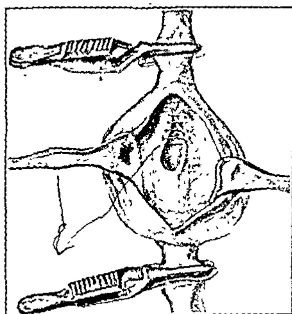


Fig. 48.—Restorative endoaneurismorrhaphy of Matas.

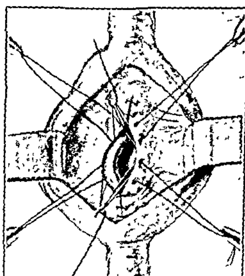


Fig. 49.—Reconstructive endoaneurismorrhaphy of Matas

whether bleeding from the branches in the wall of the sac has been controlled. If there is no bleeding, the sac is obliterated by rows of sutures, the first row running preferably from one arterial opening to the other. After this has been finished, another more superficial row is placed. The manner of treating the sac after the

two tiers of obliterative sutures have been placed depends largely upon the condition and size of the sac and must of necessity be left to the judgment of the surgeon. The essential features are to close the arterial openings into the sac and to place at least two rows of sutures, obliterating the sac, in so far as possible, from one of the main arterial openings to the other. After this, the recesses of the sac are folded upon themselves, or sutures are carried through a double thickness of the sac and tied in the margin of the wound. All dead space should be obliterated and the wound closed without drainage. The smooth membrane lining the inside of the sac is vascular endothelium and requires no freshening or injury to heal, but merely snug approximation as with the peritoneum. In intraperitoneal aneurisms the peritoneum is so sutured as to cover the raw surface.

Restorative endoaneurismorrhaphy (Fig. 48) is applicable when the sac is tough but pliable and when there is only one opening. In other words, when the aneurism springs from one side of the artery and involves only a small part of the arterial circumference. Such ideal conditions are not frequently encountered but when they are, the opening is sutured in such a way that the arterial lumen is preserved. The rest of the procedure is identical with the obliterative method. Practically speaking, this method is applicable only to traumatic aneurisms.

Reconstructive endoaneurismorrhaphy (Fig. 49) is recommended by Matas in cases in which the sac is tough and holds sutures well. The sac is cleaned of clots and washed out with salt solution. Matas recommended that a soft rubber catheter, well anointed with petrolatum and fitting snugly into the arterial openings, be inserted, and that interrupted sutures be placed at close intervals over the catheter. After the sutures have been placed, the catheter is withdrawn and the sutures are tied. The rest of the sac is obliterated as in the other methods. This method is very rarely applicable.

Reconstructive endoaneurismorrhaphy probably sooner or later either becomes obliterative or fails to cure. The fact that, in several instances, thrombi which formed following the reconstructive operation were later dislodged and acted as emboli is also a serious objection to this method. In experimental work under the best conditions with comparatively healthy blood vessels and using the finest sutures of silk and the finest needles, it is impossible to avoid occasional occlusion of the artery by clot, even after some experience in vascular suture. This being the case, we should not expect sutures used on comparatively coarse needles, in diseased tissue, to produce permanent patency. If there is a small single opening between the aneurism and artery, the restorative method is indicated, but the obliterative method is to be preferred to the reconstructive method.

In all methods of aneurismorrhaphy care should be taken to take no deeper bites with sutures than is necessary to secure a firm hold; otherwise, the needle may wound the accompanying vein or a nerve or may occlude collateral vessels.

There seems no doubt that endoaneurismorrhaphy is less likely to cause gangrene than is extirpation.

EXCISION OF SAC

The ideal treatment of aneurisms is to excise the sac and preserve the arterial channel. Extirpation of aneurisms of the popliteal artery followed by direct end-to-end suture of the artery has been done but is rarely feasible, for it is applicable

only when the aneurism involves a short section of the artery and the remainder of the artery must be healthy. Restoration of the channel by substituting a segment of vein for the excised section has much to recommend it and will almost certainly be used more frequently. The vein that accompanies the artery is generally used. In recent years Blakemore and others have reported the successful use of vein implants in the cure of aneurisms. This procedure also has much to recommend it and is applicable under circumstances not suitable for aneurismectomy and grafting.

OPERATIONS ON ANEURISMS OF SPECIAL ARTERIES

Aneurisms of Thoracic Aorta

Aneurisms of the thoracic aorta are the most frequent ones, as would be expected, because of the strain to which this great vessel is subjected In this location surgical treatment usually is not indicated, though in sacculated thoracic aneurisms wiring by Blakemore's technic may be worthy of trial. Abbott, Poppin, and others recommend the application of polythene or cellophane.

Guinard, of Paris, in 1904 attempted to cure an aneurism of the thoracic aorta by proximal ligation; the chest was opened posteriorly by an osteoplastic flap and a ligature was placed on the thoracic aorta just below the arch. When the ligature was tightened, pulsation in the femoral arteries stopped and the lower part of the body became pale and cold, but in a few minutes the circulation was partially reestablished However, the pressure was not sufficient to maintain renal function and the patient died. It is likely that this will practically always be the result of primary complete occlusion of this portion of the aorta, and that almost the only hope of successfully treating aneurisms of the thoracic aorta by surgery is by the use of grafts; after excision of the aneurism or more likely by using Blakemore's technic of inlay grafting.

The average duration of untreated thoracic aneurisms is a little more than a year.

Aneurisms of Abdominal Aorta

Aneurisms of the abdominal aorta, especially those above the level of the renal arteries, are infrequently amenable to treatment other than by the Blakemore method of wiring. Even this procedure has a limited scope, for aneurisms above the renal arteries involving the superior mesenteric artery or the celiac axis will in all probability result fatally if obliterated by any means Unless aneurisms of the proximal portion of the abdominal aorta are distinctly sacculated, with a small communication with the aorta, which can be closed with preservation of the lumen of the aorta and its essential branches, the outlook is poor. In aneurisms below the renal arteries, the outlook is more hopeful, but the results so far have not been good. Methods must be used which will permit extirpation or obliteration of the aneurism sac, yet maintaining adequate circulation to the lower extremities before the treatment of abdominal aortic aneurisms can be more than palliative. Excision and the insertion of grafts or the use of inlay grafts offer the greatest hope.

In the very small number of sacculated traumatic aneurisms of the aorta it is possible to do a restorative aneurismorrhaphy

We have in one instance resected the aorta from just below the origin of the renal arteries to its bifurcation, and now, six years later, there is nothing to suggest the development of other aneurisms and the patient's general health is satisfactory, but she is still partially disabled by weakness of the lower extremities, the result of severe ischemic neuritis, which followed occlusion of the aorta. This case is cited to show that at least in some instances removal of aneurisms of the distal aorta is feasible and may give prolonged relief. Efforts to cure such aneurisms will be altogether justifiable if it is possible to remove the aneurism and yet maintain an adequate circulation to the lower extremities.

Involvement of the inferior mesenteric artery apparently does not contraindicate excision or obliteration of an aneurism sac, a matter of considerable importance since that artery is involved in a large percentage of aneurisms of the distal aorta.

Blakemore's technic for inlay vein grafts is to gain control of the circulation above and below the aneurism, open the sac, evacuate the clot, and close all collaterals entering the sac, much as is done in the Matas obliterative endoaneurismorrhaphy. He then takes the segment of vein to be implanted, passes the ends through his special Vitallium cannula, turns the ends back over the cannulae, and fastens them by silk ligatures tied back of the ridges or shoulders on the cannulae. The ends are then fitted into the openings of entrance and exit of the main artery and fixed in place by silk sutures. These sutures are inserted through the wall of the artery at its junction with the aneurism, then through the cuff of vein, and finally through the opposite arterial wall, fixing the graft in place. The vein for inlay is not cut until the distance between the openings of entrance and exit is determined. Blakemore then adds 4 cm to that distance for the proper length of the venous transplant. This procedure appears to be well adapted for use in aneurisms of the distal abdominal aorta.

Innominate Aneurisms

True innominate aneurisms are apt to be amenable to radical surgery, but unfortunately many so-called innominate aneurisms are in reality aneurisms of the aortic arch, arising at the origin of the innominate artery. Surgery is naturally less satisfactory in this latter group of cases. Occlusion of the innominate artery is always a serious undertaking, but the risk increases with age, so in patients of middle age or older, all available measures for increasing the collateral blood flow should be employed. Since sympathectomy is the most important of these measures it should be done as a preliminary procedure. The greatest danger from occlusion of the innominate artery is marked ischemia of the central nervous system. Occlusion of the common carotid artery by fascia preliminary to direct attack on the aneurism is therefore advisable. Fortunately, extirpation of the stellate and the second and third dorsal ganglia and occlusion of the proximal common carotid are readily done through the same approach. If there is no adverse reaction to occlusion of the common carotid, one may attack the aneurism with reasonable assurance that the blood supply to the right upper extremity will be adequate.

In the direct attack on the aneurism it is essential that the exposure be altogether adequate, otherwise it is unlikely that the operation will be successful. Provision must be made for exposure of the bifurcation of the innominate, the entire aneurism, and the origin of the innominate from the arch of the aorta. This prob-

ably is best accomplished by resection of the medial portion of the clavicle and by splitting the sternum from the jugular notch to the level of the third intercostal space. This approach is recommended by Shumacker, who apparently has found it very satisfactory.

Traumatic aneurisms of the innominate artery may be amenable to restorative aneurismorrhaphy, and some spontaneous innominate aneurisms may be cured by obliterative endoaneurismorrhaphy, but extirpation of the aneurism usually is the procedure of choice. When an adequate exposure has been obtained, the problem should be evaluated by a careful examination of the origin of the innominate from the aortic arch and the relationship of the aneurism to adjacent important structures such as the innominate veins and the vena cava, to the trachea, the vagus nerves, etc. If resection of the aneurism is decided upon, it is advisable to section the carotid and subclavian arteries between ligatures as the first step. Additional suture ligatures should be applied to the distal segments of both these vessels. Primary occlusion of these vessels is recommended because manipulation of the aneurism incident to separating it from the adjacent structures may force some of the clot lining the sac out into these vessels, with disastrous results. After the carotid and subclavian arteries have been occluded, attention should be turned to the base of the innominate. If the origin of the innominate is greatly widened, ligatures will likely cut through. A wide strip of fascia lata wrapped around the base of the artery at least twice, then fixed by several silk sutures, is probably as safe a way as any to occlude a large communication between the aorta and innominate artery. After the communication with the aorta has been closed, the aneurism sac may be more readily and safely separated from the adjacent structures. Ligation of one of the innominate veins, preferably the right, is almost certain to be necessary. Although division of the left innominate vein between ligatures permits somewhat better retraction of the superior vena cava, it is obviously desirable to occlude the vein on the side of the arterial occlusion if possible. If, for any reason, removal of the entire sac is not feasible, a strong clamp may be placed across the sac well above the strip of fascia, and the sac may then be opened and evacuated. The closure by the fascial strip may then be reinforced by interrupted mattress sutures of silk. If the arterial wall at the base of the innominate seems in good condition, one might apply an occlusive clamp, then apply sutures somewhat as in closure of the divided ductus arteriosus. Blakemore apparently has used the latter method of closure with satisfaction in at least one instance.

Carotid Aneurisms

In carotid aneurisms, preliminary proximal fascial occlusion of the artery, as advised in innominate aneurisms, is recommended. In case occlusion by fascia produces no evidence of cerebral ischemia, a curative operation should be undertaken within a few weeks, for fascial strips may soon give way. The problem is not an easy one to decide upon, for the majority of carotid aneurisms occur near the bifurcation of the common carotid, and, if they are large, it is difficult to expose either the external or internal carotids above the aneurism, especially the latter vessel. Excision is therefore almost certain to be difficult, and in addition there is danger of interference with the cerebral circulation because of occlusion of both the external and the internal carotids.

We have treated a number of aneurisms in the region of the bifurcation of the carotid by preliminary fascial occlusion of the common carotid, followed within a few days to a few weeks by obliterative endoaneurismorrhaphy. The results have been satisfactory in all except one. In this instance, a fifty-eight-year-old man who had had two previous cerebral vascular accidents, one of them more than two years before the aneurism was first noticed, developed hemiplegia following the aneurismorrhaphy. The fascial occlusion was done as an emergency because of necrosis of the skin over the most prominent portion of the aneurism. There was no evidence of cerebral ischemia and the occlusion seemed to be complete for six or seven weeks. Unfortunately the fascia gave way at this time and bleeding recurred. Obliterative aneurismorrhaphy was performed but required more than the usual amount of manipulation, since the arterial defect involved the posterolateral surface of the vessel at the bifurcation. The operation was done under regional and local anesthesia and during the manipulation of the sac the patient showed incoordinated muscular contractions, then shortly lapsed into unconsciousness. Later he was found to have a hemiplegia. It is likely that manipulation of the aneurism forced a fragment of clot into the internal carotid. In spite of this untoward result, we feel that obliterative endoaneurismorrhaphy is the procedure of choice in the treatment of most aneurisms near the bifurcation of the common carotid artery.

Aneurisms of the external carotid are rare but do occasionally occur. In the past, the majority of them have been treated by proximal ligation alone, probably because of the difficulties encountered in their obliteration or excision. Preliminary proximal ligation, with division of the artery, is of value, for the aneurism will shrink temporarily, making excision or obliteration of the sac less difficult. Aneurisms of the common carotid or of the internal carotid arteries are of grave significance because of the disastrous effect on the brain that often follows when one of these arteries is occluded. In young patients with elastic arteries ligation of the common carotid is comparatively safe, but in later life, particularly when there is advanced arteriosclerosis, cerebral symptoms frequently occur after occlusion of the internal carotid or common carotid arteries. It has been found that when cerebral symptoms do occur, prompt reestablishment of blood flow through the obstructed artery usually is effective in preventing permanent central nervous system changes Fortunately it usually is possible to detect quite early evidence that the blood supply to the brain is inadequate. It is therefore important to do a preliminary occlusion by a method which is reversible, before permanently obstructing the common or internal carotid arteries. The artery, usually the common carotid, should be exposed under local anesthesia and subtotally occluded, preferably by a strip of fascia (Fig 50) or by a Halsted metal band. Local anesthesia is used so that early symptoms of cerebral ischemia will not be confused with the effects of general anesthesia. If cerebral symptoms develop, the occluding fascia or band must be removed at once If no adverse symptoms develop, permanent occlusion should be done within a few weeks. This is especially indicated if fascia is used, since occlusion by fascia frequently is spontaneously released after a matter of weeks. Cerebral symptoms sometimes appear after several days though they are usually manifest within less than twenty-four hours. Even when evidence of

cerebral ischemia is noted only after several days, the fascia or band still should be removed, for there still remains a reasonable chance that the circulation will be reestablished. If subtotal occlusion is not borne well, one should consider the advisability of excision of the aneurism and the use of a vein graft or the use of an inlay vein graft as described by Blakemore.

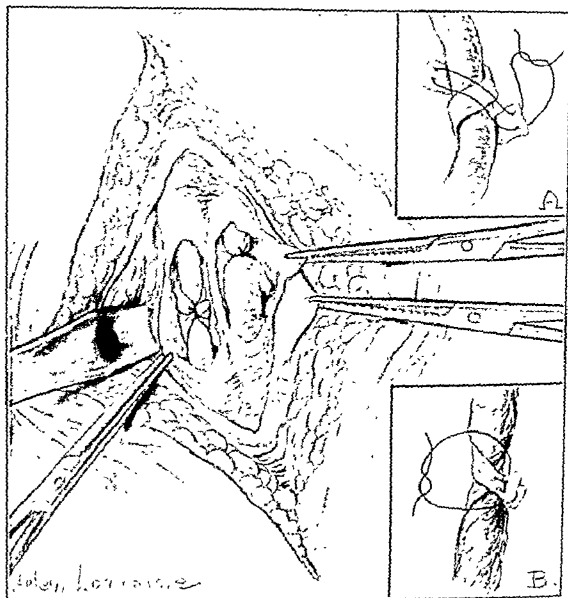


Fig 50.—Use of strip of fascia lata for occlusion of an artery. Note that the vein has been ligated *A* and *B*, Method of application of fascia.

Subclavian Aneurisms

The treatment of subclavian aneurisms depends upon a number of factors: the size of the aneurism, the portion of the artery involved, whether on the right or left side, and the age and general condition of the patient.

Aneurisms of the first part of the right subclavian artery usually will require resection of the medial end of the clavicle and section of the upper part of the sternum. Large aneurisms of this portion of the right subclavian artery present many of the problems presented by innominate aneurisms and require essentially the same approach and treatment. Proximal occlusion usually will be somewhat less of a

problem, but, in the presence of a large sac, even this may be little different from innominate aneurism. Endoaneurismorrhaphy is at times feasible and should be used when it is possible to do so, for it may enable one to save some of the very important collateral vessels such as the vertebral artery, the internal mammary artery, and the thyrocervical axis. Aneurisms of the left subclavian artery usually present the same problems and require the same treatment as those on the right side, but when they occur near the origin of the artery from the arch of the aorta, a transpleural approach through the left second interspace may make it possible to occlude the artery proximal to the sac with somewhat less difficulty. Resection of a portion of the clavicle usually will be necessary in order to gain control of the circulation distal to the aneurism.

Aneurisms of the distal part of the subclavian artery and the proximal section of the axillary artery usually require extensive resection of the clavicle. One of the principal difficulties encountered in connection with aneurisms in this area is involvement of the cords of the brachial plexus. In traumatic aneurisms the cords of the plexus are frequently injured, and in spontaneous aneurisms they may be severely damaged by the expansile pressure of the aneurism. The close relationship with these large nerve trunks makes wide exposure and complete hemostasis altogether necessary. Small aneurisms in this area probably are best treated by excision; large ones may be best handled by obliterative endoaneurismorrhaphy. However, if there has been primary nerve injury, excision of the sac may be obligatory for exposure of the injured nerves.

In subclavian and axillary aneurisms sympathectomy is advisable, preliminary to or at the time of operation on the aneurism.

Aneurisms of the distal part of the axillary artery or of the proximal segment of the brachial artery may be treated by endoaneurismorrhaphy or by extirpation of the sac. In certain traumatic aneurisms reconstructive aneurismorrhaphy is feasible and is the operation of choice. When the axillary artery is occluded, it is advisable to occlude the axillary vein

Iliac and Femoral Aneurisms

The treatment of aneurisms of the common iliac arteries has much the same dangers as does the treatment of aneurisms of the terminal aorta, for the common iliacs are only a few centimeters in length, so before one can excise or obliterate the sac it is often necessary to occlude the terminal aorta. In aneurisms of the internal iliac arteries, especially those arising near the bifurcation of the common iliacs, it is necessary to expose and temporarily occlude the common iliac, the external iliac, and the opposite internal iliac Either excision or obliterative aneurismorrhaphy should prove satisfactory. The ureter is almost certain to be involved by scar, so it should be exposed proximally and distally if the aneurism is to be excised Left iliac aneurisms are somewhat more difficult because of the proximity of the branches of the inferior mesenteric artery. They should be exposed and protected.

Preliminary proximal occlusion by fascia may be helpful in iliac and common femoral aneurisms. Lumbar sympathectomy should be done at the time of the fascial occlusion. Testing the efficiency of the collateral circulation and performing sympathectomy preliminary to definitive operations for aneurisms are always sound

measures, but they are especially indicated when aneurisms involve the common and internal carotids, the common iliacs, the common femorals, and the popliteal arteries.

Since aneurisms of the iliac arteries are supported anteriorly only by peritoneum, they tend to enlarge rapidly and are more prone to rupture than are aneurisms surrounded by muscle and fascia *Iliac aneurisms should therefore be operated upon promptly.*



Fig. 51.

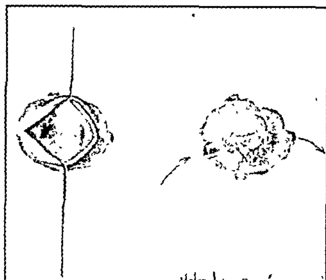


Fig. 52.

Fig. 51.—Traumatic aneurism of the superficial temporal artery.

Fig 52.—The excised sac of the traumatic aneurism shown in Fig. 51. Note the afferent and efferent vessels.

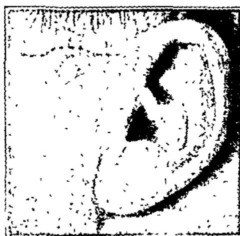


Fig 53

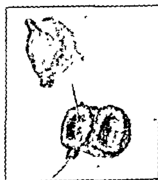


Fig. 54

Fig. 53.—The second case of traumatic aneurism of the superficial temporal artery

Fig. 54—*Drawing of the excised sac shown in Fig 53*

It is exceedingly difficult to obtain satisfactory hemostasis during operations upon aneurisms of the common femoral artery *without temporary* occlusion of the external iliac artery This is best accomplished through an extraperitoneal approach. *The number of important collateral vessels in this area, including the profunda femoris artery, makes* excision of the aneurism sac hazardous. Endoaneurismorrhaphy usually is the operation of choice. If extirpation of the aneu-

rism is undertaken, the surgeon should be prepared to reestablish the continuity of the femoral artery by vein graft.

Aneurism of the superficial femoral artery may be treated satisfactorily by obliterative endoaneurismorrhaphy or by excision of the sac, if the important collateral vessels are carefully protected.

Popliteal Aneurisms

Popliteal aneurisms are said to comprise about one-third of all spontaneous aneurisms other than those arising from the aorta. In the treatment of aneurisms in this area extirpation of the sac should be done only if the surgeon is prepared to maintain the continuity of the popliteal artery by vein graft Also it is important that a preliminary lumbar sympathectomy be done. When combined with sympathectomy, obliterative endoaneurismorrhaphy usually gives satisfactory results. Incisions for the exposure of popliteal aneurisms may be made transversely or in the form of an S, but straight incisions directed perpendicularly across the popliteal crease are inadvisable as they lead to contractures at the level of the crease.

Popliteal aneurisms may involve the whole of the artery in the later stages, but in the early stages they are often of the saccular form in which a very small portion of the artery is affected. Under such circumstances it may be possible to excise the aneurism and unite the ends of the artery by suture. Operations upon aneurisms arising in the upper part of the popliteal space are less likely to be followed by ischemic gangrene than upon those arising in the lower portion of this space.

Aneurisms of Smaller Arteries

Aneurisms of the smaller arteries, such as the radial, ulnar, or tibial arteries, usually are best treated by proximal and distal ligation of the artery and extirpation of the sac. The circulation from the companion artery usually is abundant and hemorrhage can be controlled by tourniquet, so excision of the aneurism is safe and the most certain means of cure. Aneurisms of such vessels as the superficial temporal artery also are best treated by excision (Figs. 51, 52, 53, and 54).

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CHAPTER 10

ARTERIOVENOUS FISTULAS

QUADRUPLE LIGATION AND EXCISION; TRANSVENOUS ARTERIORRHAPHY

I. A. Bigger

An arteriovenous aneurism or fistula is a lesion in which there is an abnormal communication between an artery and a vein. Two forms of arteriovenous aneurisms are described: varicose aneurism, in which the communication between the artery and vein is indirect in that a sac exists between the two vessels; and aneurismal varix, in which the blood flows directly through an opening from the artery into the vein. There are many combinations: There may be a sac involving the wall of the artery opposite the communication with the vein, or there may be two sacs, one communicating with the artery alone and one between the artery and vein. Also there may be a sac involving the wall of the vein opposite the fistula. Both vessels become dilated proximally, unless the parts around them form a rigid support.

The most frequent cause of arteriovenous aneurism is direct trauma, bullet wounds and stab wounds being the cause of most of them. The penetration of large contiguous vessels, such as the femoral artery and vein, is particularly apt to be followed by a persistent fistula between them. Formerly, when blood letting was in vogue, arteriovenous aneurism between the brachial or the ulnar artery and a vein was comparatively frequent. Elkin has called attention to the development of arteriovenous fistulas following surgical trauma. Fractures or indirect injuries rarely result in arteriovenous aneurism. The spontaneous development of a fistula between an artery and vein is also rare and is probably always due to degeneration in the wall of the artery; as, for example, when an aneurism perforates into an adjacent vein

Because of the activity of the circulation in the vicinity of arteriovenous fistulas, the result of the great difference in pressure between the arterial and the venous trunks, clots rarely form and the prospect of spontaneous cure is slight. The liability to rupture depends to some extent upon the size of the sac but is mainly dependent upon the character of the surrounding tissues An aneurismal varix rarely ruptures.

That portion of the artery distal to a fistula usually decreases in size as it has to carry a smaller volume of blood than normal. Some of the blood passes through the fistula to the vein and is returned directly to the heart. The proportion of arterial blood entering the vein through the fistula is dependent upon the size of the opening, for through the fistula into the vein and back to the heart is the path of least resistance. The proximal segment of the artery usually is dilated

This was formerly supposed to be due to atrophy of its walls but is now believed to be due to the large column of blood which it must carry; for not only must it furnish blood to the parts distal to the fistula but it must also supply the abnormal communication between the artery and vein. As Holman has pointed out, the segment of artery distal to the fistula may become dilated if for some reason it is impossible for the proximal segment to dilate. This also is due to the passage of a larger volume of blood which here comes through collateral channels, entering the artery distal to the fistula. The fistula creates a path of lessened resistance and when the blood passing through the undilated segment of artery is not sufficient to supply the demands of this abnormal channel, that blood entering the main artery immediately distal to the fistula is drawn back and returns to the heart by way of the fistula. The vein also is dilated, distally as far as the first valve and centrally as far as the vena cava or even the heart. The wall of the vein gradually thickens and becomes more like the wall of an artery; in long-standing cases it may be difficult to distinguish the proximal segment of the vein from the artery. Sometimes in the large veins immediately distal to the fistula the function of the valves is destroyed by the increase in pressure of the blood in that area. This, in turn, may cause swelling and further interference with the circulation to the tissues distal to the fistula. Nutritional disturbances in the form of ulcers or even gangrene may appear because too little blood reaches the arteries distal to the fistula. The degree of local disturbance depends upon the location as well as upon the size of the arteriovenous communication. A small fistula will cause but little disturbance, whereas a large one may lead to rapid tissue changes from impaired nutrition

A large opening between large vessels may so greatly increase the volume of blood to the heart that a rapid dilatation of the heart ensues. That the early change in the size of the heart is due chiefly to dilatation is shown by its rapid return to normal or near normal upon closure of the fistula. Fistulas of long duration are apt to produce both cardiac dilatation and hypertrophy.

The signs of an arteriovenous aneurism may appear immediately after the injury or after the lapse of some days or even weeks Usually the clots and the edema in the adjacent tissues will reduce the size of the communicating channel for several days and thus obscure the picture

Most surgeons who have had considerable clinical experience with arteriovenous aneurism have felt that it is better not to operate upon the majority of such cases for several weeks or even several months unless the patient is seen immediately after the trauma If there is rapid cardiac dilatation or evidence of insufficient blood supply distal to the lesion, early operation becomes necessary. If the patient is not seen immediately after the injury, and none of the indications for early operation is present, he is put at rest to protect the heart and to aid the circulation distal to the fistula Conservative treatment may be continued for two or three months, to allow time for the swelling in the tissues adjacent to the fistula to subside and for all the bacteria in the damaged tissues to be destroyed, as well as for the development of the collateral circulation. The presence of a fistula between an artery and a vein is a tremendous stimulus for the development of the collateral bed, and Bosher has shown that collateral development is far more rapid than was formerly thought.

If the condition is recognized at once and the attending circumstances are satisfactory, it would seem best to *operate as soon after* the injury as possible. In immediate operations the vessels should be sutured *according to the* technic described in the chapter on suturing blood vessels. Unfortunately, most of these cases occur in military surgery or in civil practice under circumstances *which do not* permit such treatment. If operation cannot be done within a few hours *after the* injury, it is better to postpone it for several weeks because of the danger of infection and also because the changes in the tissues, including the walls of the vessels, make it difficult to do a satisfactory repair. One disadvantage of prolonged con-



Fig. 55.



Fig. 56.

Fig. 55.—Horsley's forceps for lateral blood vessel suturing.
Fig. 56.—Method of applying the forceps.

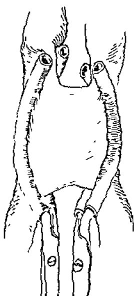


Fig 57

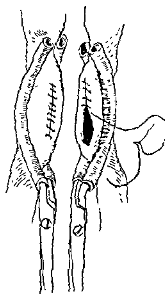


Fig 58

Fig. 57.—The vein and artery have been occluded with the forceps and the communication is about to be severed

Fig. 58.—The communication between the artery and vein has been severed and the openings in the vessels are being sutured.

servative treatment is the fact that the scar tissue may render the vessel walls tough so that they are difficult to penetrate with fine arterial needles. In fistulas of very long standing, the walls of the vessels immediately adjacent to the fistula may even show considerable calcification.

Ligation alone has not proved satisfactory in the treatment of arteriovenous fistulas. Proximal ligation of the artery alone frequently leads to gangrene, so this procedure is absolutely contraindicated. Distal ligation alone can only do harm.



Fig 59—Arteriovenous aneurism involving the left femoral artery and vein, near the inguinal ligament.

Proximal ligation of the artery and vein is sometimes indicated (Fig. 50), as, for example, when infection develops shortly after the injury, giving rise to the danger of serious hemorrhage. Under such circumstances ligation of both vessels proximal to the field of infection may be necessary, but this should not be expected to cure the fistula. Quadruple ligation, tying the artery and vein both proximally and distally with extirpation of the fistulous area, is the most certain means of obtaining a cure, and after a lapse of a few weeks this operation can be carried out with

little fear of acute ischemia in the tissues distal to the fistulous area. A possible exception to this rule is found in carotid artery-internal jugular vein fistulas.

However, while the presence of a fistula for a few weeks or months almost assures an adequate collateral circulation for the time being, it does not avoid the danger of chronic circulatory deficiency developing after excision of the fistulous area with interruption of the main artery. This development is especially noticeable when the main artery to a lower extremity is occluded. Bigger, Herringman and Rives, Blakemore, and Freeman have been impressed with this development in



Fig 60.—Transvenous arteriorrhaphy in fistula between common carotid artery and internal jugular vein. The vein has been ligated above and below the fistula and the artery temporarily occluded by tapes.

patients Bosher and Bigger have shown in experimental animals that excision of the fistula is followed by a decided and relatively rapid regression of the collateral bed. It seems desirable, therefore, to preserve main stem arteries, especially those to the lower extremities, whenever it is possible to do so.

Theoretically, the ideal treatment is restoration of the lumen of both artery and vein, but it is doubtful whether preservation of the lumen of the vein is of sufficient importance to justify the increased danger of embolism which this entails.

However, if it is possible to secure complete hemostasis, some surgeons prefer to dissect free the artery and vein and to suture the wound in each vessel (Figs. 55, 56, 57, and 58). This, of course, is permissible only when the tissues around the wounds in the vessels are in good condition, without calcium deposits or excessive scar tissue (Fig. 59).

The operation described by Matas, transvenous repair of the arterial opening, is the procedure of choice in many cases. The technic for this operation as evolved by Matas and Bickham is relatively simple when it is possible to obtain complete hemostasis. The vein is opened opposite the fistula and the opening in the artery is sutured with fine silk on curved needles as in restorative endoaneurismorrhaphy. The vein is ligated above and below the lesion, and the walls of the intermediate venous segment are sutured in layers as a reinforcement over the arterial suture line (Figs. 60, 61, and 62).

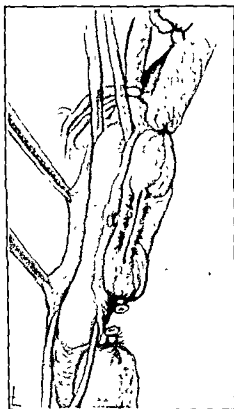


Fig 61.

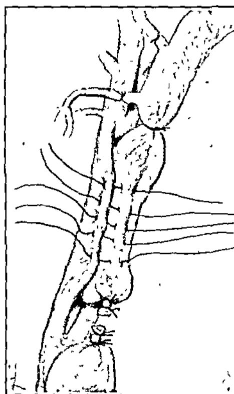


Fig. 62.

Fig 61.—Transvenous arteriorrhaphy. Repair of opening in vein.

Fig 62.—Transvenous arteriorrhaphy Suture of wall of vein to vascular sheath to add strength to closure.

Freeman has devised a method for preservation of the main stem artery which is applicable in some cases which are not suitable for transvenous repair, and which may prove superior to the Matas-Bickham operation in certain cases. Instead of opening the vein for repair of the arterial opening, Freeman dissects the two vessels apart and excises the scarred rim of arterial wall adjacent to the fistula. He then closes the wound transversely. The possibility of difficulty from the slight to moderate angulation of the artery seems remote.

These operations may be carried out under a tourniquet when the lesion is in an extremity, but in certain locations this is obviously out of the question. The

inability to use a tourniquet does not preclude operation, for the vessels can be very carefully dissected out, both proximal and distal to the fistula, and temporarily occluded by the application of Crile clamps or by the use of tapes, while the repair is being done. Operations done under such circumstances are more tedious and time-consuming, and absolute hemostasis is necessary as the operation progresses. The greatest care should be exercised to avoid injury to either of the major vessels until the danger of serious hemorrhage is obviated by the occlusion of these vessels above and below the lesion.

The treatment of arteriovenous aneurisms is influenced by a number of factors: the size of the involved vessels, the size of the communication, the age and general condition of the patient, especially as regards the heart, and the duration of the fistula at the time operation is considered. The condition of the heart is of especial importance in patients who have large fistulas between large vessels. As stressed by Holman, the sudden and sometimes marked rise of blood pressure which follows occlusion of the fistula may prove too much strain upon a seriously damaged heart. However, the rise of pressure is transient, so the use of certain relatively simple measures largely avoids this danger. The vein may be partially occluded proximal to the fistula, then after a few minutes completely blocked. After a short time the artery is occluded with distinctly less rise in pressure than would have occurred with primary arterial occlusion. Moderate preliminary dehydration will accomplish much the same purpose if the rise in pressure is the result of an increased blood volume. In case of emergency venesection is advisable.

In addition to the factors just mentioned, the specific vessels involved are of importance. Fistulas between the common carotid artery and the internal jugular vein apparently do not develop the rich collateral bed found in connection with fistulas between other vessels. For this reason, an especial effort should be made to preserve the lumen of the carotid artery. This is done more safely by first carefully isolating the artery and vein above and below the communication, then temporarily occluding them by Crile clamps or by tapes. Either the Matas-Bickham or the Freeman technic may be used, depending upon which seems better suited for the particular case.

In the important vessels of the upper extremities the Matas-Bickham type of procedure may be used, but quadruple ligation of the vessels and excision of the fistulous area are less likely to give symptoms than would the occlusion of vessels of corresponding size and importance in the lower extremities When preservation of the main stem artery is not feasible, excision of the fistulous area should be accomplished with as little interference with the collateral channels as possible.

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CHAPTER 11

VARICOSE VEINS; VENOUS THROMBOSIS; OBSTRUCTION OF THE LYMPHATICS OF THE EXTREMITIES

BENJAMIN W. RAWLES, JR.

VARICOSE VEINS

Varicosities of the superficial veins of the legs often cause great discomfort and result in serious complications. Successful treatment depends on an understanding of the pathophysiologic changes and the application of the proper therapy in each case. Blood returns from the lower extremities through two systems, the deep venous system and the greater and lesser saphenous veins of the superficial system (Fig. 63). The great saphenous empties into the common femoral vein of the deep system, and the lesser saphenous into the popliteal vein. In addition, there are communicating veins between the two systems at various levels in the extremities. Blood normally flows upward from the dependent extremity as a result of several factors: first, the pressure that carries through the capillary system from the arterial to the venous side; second, valves that prevent the regurgitation of blood after it has obtained a level or that prevent reflux flow from the deep to the superficial veins; third, the sucking effect of the negative intrathoracic pressure; and, fourth, the massaging action of the muscles through which the deep veins flow. The superficial veins are supported only by skin and subcutaneous tissue and are therefore much more likely to become dilated when subjected to prolonged or abnormal pressure.

The incompetent valve is the key to the disease of varicose veins. Valves may become incompetent as a result of long-standing increased venous pressure or when they are involved in a degenerative process such as thrombophlebitis. When the valves are incompetent, blood regurgitates from the deep veins into the superficial veins with resulting dilatation of this latter system. Incompetent valves in the main trunk of the greater saphenous allow blood to regurgitate into it from the femoral; blood regurgitates from the popliteal into the lesser saphenous when the valves are incompetent in that system When the valves in the communicating vein become incompetent, blood flows in reverse from the deep to the superficial vein Blood also may abnormally flow from one saphenous system into the other and result in dilatation of the veins of the other system

Unfortunately, it has not been possible to correct the pathologic changes existing in the disease, and therefore treatment is based on either the obliteration of involved veins with a sclerosing solution or a surgical attack, which divides and ligates the superficial vein at its connection or connections with the deep system

and sometimes further strips the main trunk of the vein from the extremity. Surgical treatment is sometimes supplemented by injection therapy. The last half century has seen a complete swing of the pendulum in treatment Removal of segments of veins was popular at the beginning of the century, but in time it gave way to the injection of sclerosing solutions. Because of recurrences after injection therapy, it was largely replaced in the 1930's by division and ligation of the greater saphenous at the foramen ovale and also of the lesser saphenous in the popliteal space when indicated. Sclerosing solution was either retrogradely injected into the system at that time or all palpable and visible veins were injected at a later time.

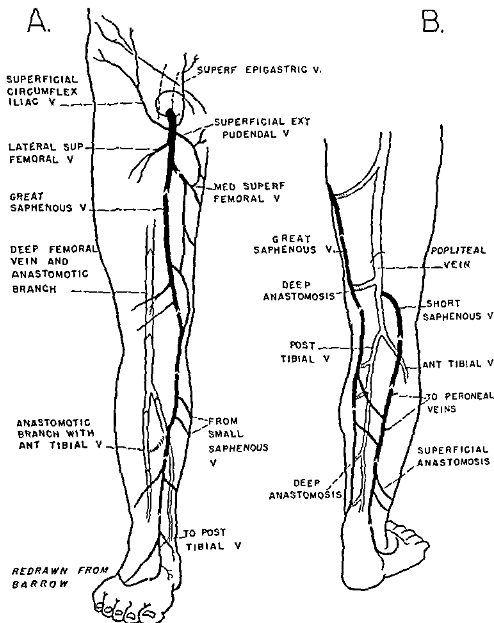


Fig 63.—Diagram showing the great and short saphenous veins and their tributaries.

This method has proved satisfactory in some cases but in spite of careful selection of patients, there have been recurrences. Recurrences may result for the following reasons: failure to divide and ligate all branches of the greater saphenous at the foramen ovale; failure to recognize a connection between the greater saphenous and the femoral in the thigh at a level below the foramen ovale; failure to recognize

incompetent communicating veins between the two systems in the lower leg; and failure to recognize a dilated lesser saphenous vein with or without connections with the greater saphenous vein. Because of the unsatisfactory results with high division and ligation, therapy today also includes extirpation or stripping of the main trunk of the greater saphenous from the groin to the internal malleolus. In addition, every effort is made to recognize all incompetent communications so that these connections can be divided and ligated. The lesser saphenous is also divided and stripped when there is evidence of involvement of this system. Residual dilated veins are obliterated in some instances with a sclerosing solution although it must be borne in mind that there is danger of producing a deep venous thrombosis if the solution flows through a communicating vein into the deep system.

Each patient must be carefully studied and evaluated before any therapy is undertaken. The status of the deep venous circulation should be determined since superficial veins dilate sometimes as a result of their carrying a greater volume of the returning venous blood following deep vein thrombosis, in which case other surgical procedures may be indicated. Two tests are helpful in determining whether or not the deep veins are adequate. A tourniquet is applied above the knee tight enough to obliterate the greater saphenous and the patient is allowed to walk about. If no discomfort is experienced with the superficial group blocked and the varicose veins empty, the deep veins are probably patent. In the other test, the patient wears an Ace bandage several days and, again, if there is no discomfort with the superficial veins compressed, the deep veins are assumed to be adequate. The therapy of chronic thrombophlebitis of the deep veins is discussed later.

One must also be certain that the arterial circulation to the extremity is adequate. A lumbar sympathectomy may be indicated in some patients in order to improve the arterial circulation before proceeding with any vein surgery. This may be necessary in patients with chronic ulcers due to chronic thrombophlebitis of the deep veins, particularly when spasm is a factor.

Cellulitis of the leg and infected ulcers are cleaned up when present with hot wet dressings of boric acid or magnesium sulfate solution and antibiotic therapy before undertaking definitive surgery. Many ulcers heal promptly following the vein surgery, but occasionally healing may be so delayed because of the large size of an ulcer or the great amount of scar tissue about it that it is best to excise the ulcer and cover the defect with a split skin graft.

It is important to check the general cardiovascular status and to determine whether or not such systemic diseases as syphilis and diabetes mellitus are present. Some chronic ulcerations of the lower leg are malignant. This should be borne in mind and biopsies should be made of any suspicious lesions.

Every case should be carefully studied with tourniquets to locate the site of insufficiency even though one is planning to do a stripping operation. The Trendelenburg test or some modification of it is of value in locating the sites of incompetency. The modified Trendelenburg test, using multiple tourniquets, is probably of the greatest value (Fig. 64). With the leg elevated above the level of the heart in order to empty all superficial veins of blood, three tourniquets are applied snug enough to obliterate the superficial veins. The first tourniquet is applied just distal to the saphenofemoral junction in the upper thigh, the second

is applied above the knee, and the third just below the knee. The patient is then allowed to stand, and if it is found that previously identified varicose veins of the lower leg fill within less than thirty seconds, there are undoubtedly incompetent communicating veins between the deep and superficial systems in the lower leg.

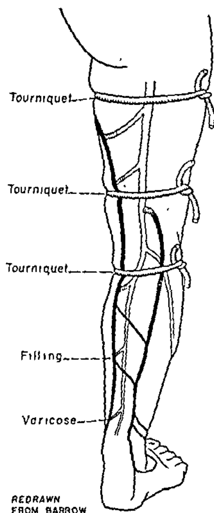


Fig. 64—Method of carrying out modified Trendelenburg test with the three tourniquets in place.

The lowest tourniquet is then released. If previously empty veins fill following this, it indicates that there has been regurgitation of blood through the lesser saphenous vein. The middle tourniquet is next removed. If previously empty veins fill following this, there are undoubtedly incompetent communicating deep veins between the deep and superficial systems in the thigh. If veins fill following release of the upper tourniquet, it indicates that blood has regurgitated into the system through the saphenofemoral junction. The Mahorner-Ochsner test may also be of value in some cases A tourniquet is applied at various levels and the patient is allowed to walk about. If the veins empty with exercise, it indicates that there are no incompetent veins below the level of the tourniquet. The level of the tourniquet may gradually be adjusted upward until the level of the incompetent vein is located. If the incompetent point is at the saphenofemoral junction, the veins will empty with exercise when the tourniquet is applied at the highest possible point about the thigh.

Injection of Veins With Sclerosing Solution

Injection therapy as the only method of treatment is reserved for minor varicosities when the Trendelenburg test is negative and the reason for obliterating the vein is primarily a cosmetic one. It has already been stated that residual superficial varices should be obliterated after high division and ligation or stripping of the veins.

There are a number of good sclerosing solutions available. Sodium morrhuate, Monolate, Sylnasol, Sotradecol, and other solutions have all been used with success. A very small amount of solution should be injected the first time to determine whether or not the individual is sensitive to the solution. After this, 2 to 5 c.c. are injected at weekly intervals. A short beveled hypodermic needle is used. Great care must be used to prevent injection or leaking of the solution into the surrounding tissues, for otherwise a severe local reaction or actual sloughing of the tissues may result. The more peripheral veins are injected first. The needle is inserted into the selected vein with the patient standing. It is best then to milk the blood out of the vein with the thumb or to have the patient recline in order to empty the veins before injecting the solution since the maximum reaction will occur in an empty vein. An attempt is made to block a segment of veins to be injected above and below the point with the fingers in an effort to trap as much of the solution in this area as possible. Pressure is then applied over the site of injection with a small gauze pad for twenty-four hours. Elastic bandages or stockings should be worn throughout the period of injection therapy.

Division and Ligation of the Greater Saphenous at the Foramen Ovale

This may prove to be sufficient therapy if it is found that the veins do not fill promptly when the patient arises to a standing position with a tourniquet about the upper thigh previously applied with the leg elevated above the heart level. The addition of a low division and ligation of the greater saphenous in the lower thigh or about the knee to the high division and ligation is a useless procedure in our experience. Obviously it is a useless procedure if there are no channels from the deep system to the saphenous trunk between the site of the high and the low division. If there are connections between the two levels through which blood regurgitates, collateral channels will rapidly develop about the site of the low division and ligation. The actual communication must be divided and blood must not be allowed to regurgitate into the saphenous vein. Stripping of the greater saphenous trunk and the division and ligation of all incompetent communications are the best way to accomplish this. Division and ligation of the greater saphenous may be performed under local anesthesia in many instances. This allows the patient to become ambulatory immediately, which is very desirable. The procedure should be carried out in the operating room. Stripping of the vein requires a general anesthetic. Pentothal Sodium supplemented by ethylene or nitrous oxide is preferred, but spinal or gas-oxygen-ether mixtures may be used.

An incision beginning at a point where the femoral artery can be palpated as it emerges from beneath Poupart's ligament and extending downward and slightly mesial for 8 to 10 cm. is preferred to a straight vertical incision (Fig. 65). The incision is carried down through the superficial fascia and the main trunk of the greater saphenous vein is exposed. The femoral vessels lie beneath the deep

fascia in the femoral sheath and there should be no confusion as to their identity, although Luke and Miller have reported 21 disasters as a result of either the ligation, division, or retrograde injection of the femoral artery. Dissection of the branches of the saphenous is greatly facilitated at this point by dividing the main trunk between clamps. By holding up on the proximal end of the vein, one is able to identify the branches and divide and ligate them with ease. A small artery from the femoral runs across the saphenous vein near its junction with the femoral

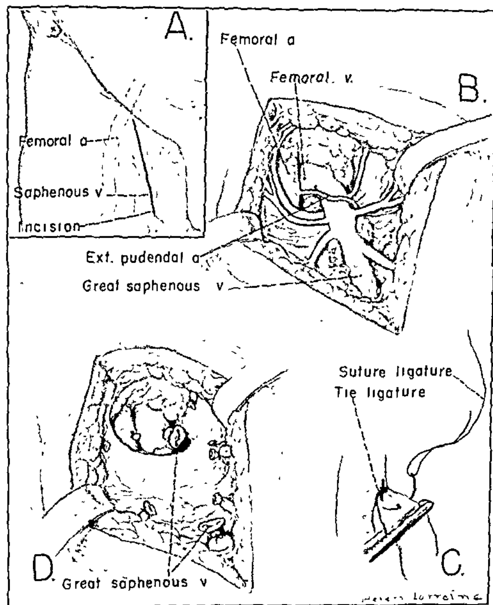


Fig. 65 —Division and ligation of saphenous vein *A*, Line of incision in relation to the vessels *B*, Dissection of the femoral vein and artery and their tributaries. *C*, Method of ligating and transfixing the larger vessels. *D*, The saphenous vein and its tributaries have been ligated and divided and small segments have been removed

and division and ligation of this may be necessary for adequate exposure The number of branches of the greater saphenous varies from two to five, and it is essential to divide and ligate all of them. The saphenofemoral junction is carefully identified before two hemostats are applied close to the junction, care being taken not to leave any of the saphenous as a blind channel in which a thrombus

could form and eventually propagate into the femoral. The upper end of the vein is first ligated with a free ligature of 30 cotton and the clamp closest to the femoral is removed. A suture ligature of the same material is next placed distally to the first ligature and the second clamp is removed. This ligature is placed distally to the free ligature in order not to have a ligature lying within the lumen of the vessel which might be the nidus of a thrombus. Approximately 10 cm. of the saphenous trunk is removed, and the distal end is doubly ligated in the same manner as the proximal end. Cotton or silk is preferred, but catgut of the appropriate size may be used. The incision is closed in layers with interrupted sutures in the fascia, subcutaneous tissue, and skin.

The retrograde injection of sclerosing solution into the distal vein is not advocated because of the severe reactions that sometimes follow this procedure, but residual veins may be injected later.

Stripping of Greater Saphenous Vein

If the greater saphenous is to be stripped, it is a good idea to extend the groin incision downward for another 5 cm in order to expose a large branch from the mesial aspect of the thigh that joins the great saphenous in the upper third of the

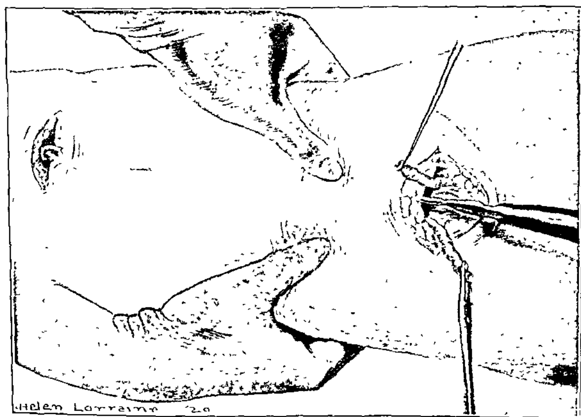


Fig. 66—Mobilizing a varicose vein and stripping it from one incision to the other by method of C. H Mayo

thigh. This branch is divided and ligated rather than stripped because it is difficult to apply pressure satisfactorily to control bleeding in the upper thigh. A number of stripping technics have been described. One of these uses a periluminal instrument (Mayo) which breaks away the branches as it is passed downward around the vein (Fig. 66). Another technic uses an intraluminal instrument. Several instru-

ments of this type have been devised. The instrument is passed down the lumen of the vessel and all branches are stripped away, then it is withdrawn, inverting the vein on itself. The vein should be removed, if possible, from the groin to the region of the internal malleolus. Immediate pressure is applied to prevent bleeding from the ends of the torn branches. Some surgeons prefer to expose the greater saphenous at the internal malleolus and to pass the stripper upward from this point because the valves and the branches theoretically offer less obstruction to the

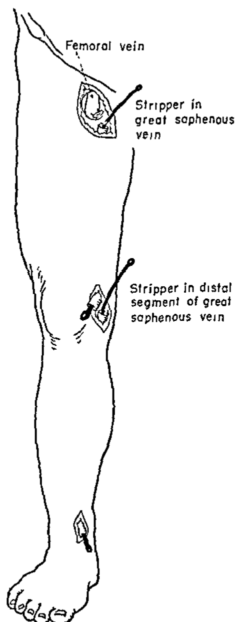


Fig. 67.—Diagram showing use of Emerson stripper for varicose veins.

passage of the stripper. A third technic employed by some surgeons uses no special instrument but depends on finger stripping. The main trunk is freed through the groin incision as low as possible, care being taken to divide and ligate all branches. A second incision is made at the level to which the vein has been stripped by the finger and in stepladder fashion the vein is dissected with the finger from one incision to the next until the entire trunk has been removed. This technic divides

and ligates all branches and so results in absolute hemostasis, but, on the other hand, it is tedious and time consuming.

The intraluminal stripping technic is generally employed today. One instrument (Emerson) is made of choke wire and has an olive tip at the end. The pliable wire allows the instrument to adopt itself to tortuous channels (Fig. 67). The intraluminal stripper, devised by Babcock, is made in sections with a semirigid shaft (Fig. 68). It may be possible to pass this instrument from the groin to the distal third of the lower leg, but an obstruction is often encountered first in the lower third of the thigh where a number of branches join the main trunk. An incision is made over this point and the branches are carefully divided and ligated.

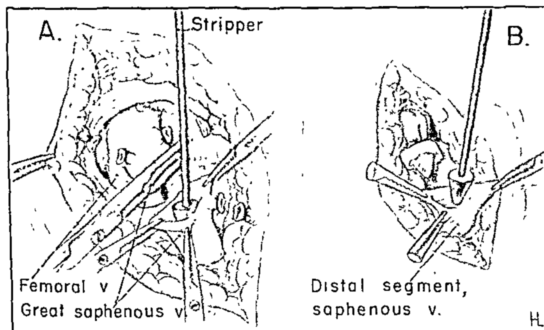


Fig. 68.—Insertion of Babcock's semirigid vein stripper: *A*, in the femoral region; *B*, in the distal segment of the saphenous vein.

The main trunk is divided and a heavy ligature is tied about the upper end of the divided vein above the conelike tip of the stripper. The stripper is not withdrawn upward until after another segment of the stripper has been passed downward from this point An obstruction may again be encountered in the upper third of the lower leg where a number of branches join the trunk. The vein is again exposed and the branches are divided and ligated if this is the case. If the second segment of the stripper cannot be guided on beyond this point, the main trunk is again divided and a third segment is passed downward to the region of the ankle if possible Since the conelike tip of the segments of the stripper are graded in size, it is possible to use a smaller size tip at the lower levels. After heavy ligatures have been tied about the vein above each tip, each section of the stripper is withdrawn, inverting the vein on itself and stripping it away from its bed. Pressure is immediately applied with a rolled towel over the course of the vein in the leg. By withdrawing all of the segments of the stripper at one time, an assistant is saved from having to apply pressure for a prolonged period of time. Occasionally the vein breaks in two, usually at the site where a branch joins the trunk. The vein is exposed through an incision at this level and another ligature is tied about the

vein after it has been picked up. All incisions are closed in layers with interrupted sutures. A pressure dressing using elastic bandages and mechanic's waste or folded abdominal pads over the course of the vein is then applied from the toes to the groin.

Patients are usually hospitalized for three or four days. They are encouraged to be up and about as soon as they recover from the anesthesia Pressure is maintained and the dressings are not disturbed except to readjust them until the seventh postoperative day when the sutures are removed. Ace bandages are worn for at least six or eight weeks after the operation. Chemotherapy is employed for forty to seventy-two hours after stripping in view of the extensive opening of tissue spaces and the possibility that extravasated blood may serve as a culture medium.

Division and Ligation of the Lesser Saphenous and Stripping of the Vein

Some surgeons have advocated stripping of the lesser saphenous vein in addition to the greater saphenous, but this should only be done when there is evidence of involvement. The lesser saphenous is exposed at its junction with the popliteal vein through a transverse incision in the popliteal space. All branches in the upper portion are divided and ligated with fine cotton The main trunk is divided close to the popliteal junction. The proximal end is doubly ligated in the same manner as described for the great saphenous The distal end is similarly ligated if the vein is not to be stripped. It may be difficult to insert a stripper, but if there is evidence of incompetent communicators, every effort should be made to remove the entire vein. Postoperative care is the same as that following operations on the great saphenous vein.

Division and Ligation of Incompetent Communicating Veins

Incompetent communicating veins are the most frequent reason for failure of therapy. In the care of the incompetent communicators in the thigh, stripping of the saphenous vein usually takes care of the condition unless there is a double saphenous trunk in the thigh and the one to which the communicator connects is not stripped. The second trunk connects with the first in the upper thigh and usually again connects to it in the upper third of the lower leg One should be on the alert for this condition This is another reason why it is preferable to expose the vein at various levels, particularly in the upper third of the lower leg, since the double saphenous trunk can often be recognized through this exposure. When there are multiple incompetent communicators between the two systems of the lower leg, all of them may not be taken care of by the stripping, and blood continues to regurgitate into segments of the saphenous system. It may be necessary to identify and then divide and ligate each of these connections separately. These connections can be picked up on physical examination, but at times phlebograms have been found to be helpful in locating them. In a few instances, it may be necessary to resort to the subfascial division and ligation of the communicators, as described by Linton. The involved veins may be in one of three groups: communicators to the posterior tibial mesially, the anterior tibial anteriorly, or the peroneal posterolaterally (Fig. 69). A longitudinal incision is made down through the fascia the length of the lower leg in the area or areas involved All branches

are divided subfascially. The operation must be done under general anesthesia, and because of the extensive dissection it is probably advisable to expose only one group at a time.

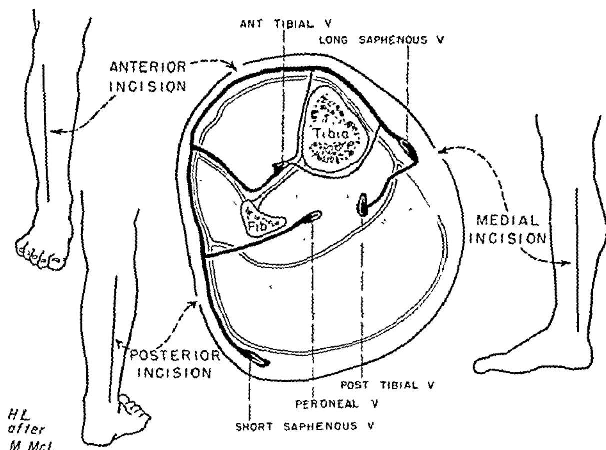


Fig. 69—Cross section through the mid portion of the lower leg and location of skin incisions, as recommended by Linton.

VENOUS THROMBOSIS

Thrombosis of veins may occur anywhere in the venous system, but this discussion is particularly concerned with the condition when it involves the veins of the lower extremity or the pelvis. Thrombosis most commonly involves the veins in the calf muscles of the legs. The condition may occur as a complication of operation, trauma, pregnancy, or any medical condition which confines the individual to bed for a long period of time

In recent years two forms of the disease have been recognized—phlebothrombosis and thrombophlebitis The former presents a minimal of inflammatory reaction, while the latter may show varying degrees of local and systemic inflammatory reaction. The conditions may only be different manifestations of the same process, but we do attempt to differentiate between the two. The clot in phlebothrombosis results from stasis and probable changes in the blood constituents which alter the clotting mechanism. The clot is not adherent to the vessel wall and easily breaks off in the blood stream, resulting in embolism. Thrombophlebitis is also caused by stasis, but other factors such as infection and trauma result in damage to the intima with the result that the clot is firmly adherent to the vessel wall. Embolism should, therefore, rarely occur in this latter condition

Clinically, one is interested, first, in preventing the development of the condition and, second, in therapy to prevent, if possible, a clot from breaking off in the venous stream and producing a pulmonary embolism. General measures should be employed in all surgical cases in an attempt to prevent thrombosis. These prophylactic measures might be classified as conservative measures. All tissues should be handled as gently as possible in order to reduce tissue damage to a minimum. Preoperatively it is important to restore the blood volume to normal in order to maintain an adequate cardiac output, which is important in maintaining good blood flow. Postoperatively, deep breathing, leg exercises, and early ambulation are important in promoting good blood flow in order to prevent stasis. If the patient has varicose veins, Ace bandages should be worn during the immediate postoperative period. Blood volume must be maintained with adequate infusions of dextrose, electrolytes, and blood. Infection must be prevented or controlled. It has been suggested by Ochsner and his associates that lowered antithrombin levels in the blood may be a factor in intravascular clotting, and since circulating antithrombin may be alpha-tocopherol, they have given alpha-tocopherol acetate and calcium gluconate prophylactically.

In addition to the general prophylactic measures, certain specific measures have been advocated. Allen and his co-workers have employed prophylactically Dicumarol in all patients aged 40 to 65 years, undergoing major surgery. These patients are given 200 or 300 mg of Dicumarol on the third postoperative day, and if there is no notable change in the prothrombin time, an additional 200 mg. is given on the fourth day postoperatively. Allen reports a reduction in the incidence of thrombophlebitis after the routine use of Dicumarol. Wise reports similar experiences. Allen also advocated the prophylactic division and ligation of both superficial femoral veins in patients 65 years of age and older before certain major surgical procedures in which there is a high incidence of pulmonary embolism Operations for carcinoma, prostatism, and nailing of fractures of the hips fall in this category.

It has been our policy to individualize the treatment for each individual case. The routine use of Dicumarol prophylactically is not advocated because of the danger of hemorrhage. Although division and ligation of the superficial femoral vein is considered a safe procedure, sequelae are not entirely absent and surgical catastrophies—damage to the arterial supply—occasionally occur Erb and Schumann have recently showed that prophylactic ligation of the superficial femoral vein is of questionable value

All nonfatal cases of pulmonary embolism should have both superficial femoral veins divided and ligated. If there is iliofemoral thrombosis, either the common iliac should be divided and ligated or the inferior vena cava should be ligated in continuity. The latter procedure should be reserved as a lifesaving measure because of the high incidence of sequelae, as recently stressed by Shea. In septic thrombophlebitis involving the pelvic veins, such as is found after postabortal or postpartum sepsis, the vena cava probably should be ligated and both ovarian veins should be divided and ligated The same procedure may be considered in cases of nonfatal pulmonary embolism when the pelvic veins following pelvic surgery are the possible site of venous thrombosis If a diagnosis of phlebothrombosis is made,

both superficial femoral veins should be interrupted at once. Such a diagnosis may have to be based on minimal clinical findings.

Acute thrombophlebitis can be treated satisfactorily in most instances by conservative measures. The limb should be elevated on a pillow and compression bandages applied. Anticoagulant therapy is started at once after first obtaining a control prothrombin time. Prothrombin time should be maintained in the range between 35 and 40 per cent of normal. If heparin is used, the clotting time should be kept at approximately fifteen minutes. Therapy should be continued until the process has subsided, which usually takes from seven to ten days. In addition to the anticoagulant therapy, some form of vasodilatation should be employed. The injection of the lumbar sympathetic trunk on the involved side with procaine, as advocated by Ochsner, is the surest way of producing such a result. However, one of the general drug vasodilators may be used although they do not give selective vasodilatation as a sympathetic block. If fever continues in spite of conservative therapy, it may be advisable to do the ligation at the indicated level.

The deep veins of the lower extremity are most commonly the site of thrombosis, but the superficial saphenous system may be involved. If the saphenous veins are the site of an acute thrombophlebitis, division and ligation of the greater saphenous at the foramen ovale or of the lesser in the popliteal system is followed by rapid regression of the pathologic process

Division and Ligation of the Femoral Vein

The patient is placed on the table with the head of the table elevated in order to increase venous pressure. This may aid in the extraction of the clot and prevent an embolus from breaking off and going to the lungs. The procedure is done usually under local anesthesia (Fig. 70). A 12 cm. longitudinal incision is made in the upper part of the anterior thigh over the femoral vessel or just mesial to the femoral pulsation, beginning at the point that Poupart's ligament crosses the vessels Superficial and deep fascia are incised and the femoral vein and its branches are exposed The superficial femoral vein lies mesial and somewhat posterior to the artery and is exposed sometimes with difficulty. Care is taken to identify carefully the profunda branch of the femoral. A heavy ligature is then passed about the superficial femoral distally and about the common femoral as a means of controlling bleeding when the vein is opened. The superficial femoral vein is then opened between stay sutures. If a thrombus is found, it is carefully extracted. Aspiration with a glass tube or catheter introduced upward into the common femoral vein is a hazardous procedure but may be employed while the head of the table is elevated. If the clot is successfully removed, there should be free bleeding from each branch when the others are compressed. If there is free bleeding from all the branches, the superficial femoral vein is divided between clamps close up to where the profunda branch joins to make the common femoral vein. Each end is doubly ligated with two ligatures of 30 cotton One of these ligatures is a transfixation ligature which is applied distally to the free ligature. If it is impossible to remove the thrombus from the common femoral, ligation should be done at a higher level. Homans has pointed out that ligation of the common femoral results in swelling of the leg because of inadequate collateral circulation about this point. Either the common iliac vein or the inferior vena cava should be ligated under this condition.

The incision is closed in layers with interrupted sutures of fine cotton. Catgut of the appropriate size may be used instead of the nonabsorbable sutures. Elastic bandages are applied to the extremity and early ambulation is employed. Even though there is no evidence of involvement of the opposite femoral system, the superficial femoral vein on the opposite side should also be divided and ligated.

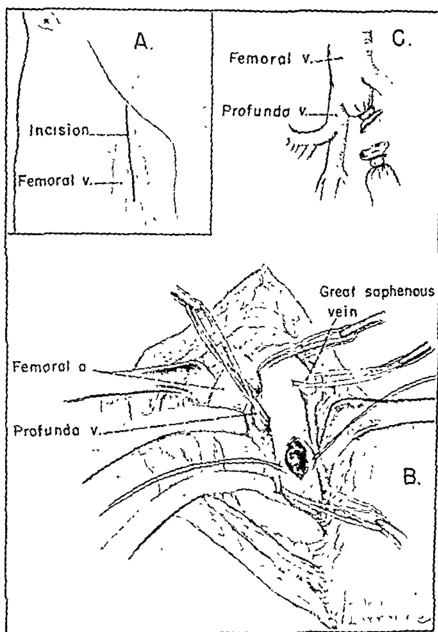


Fig 70—Division and ligation of superficial femoral vein *A*. Line of incision *B*. Incision made in the superficial femoral vein and the thrombus shown. *C*, The vein doubly ligated and divided

Division and Ligation of Common Iliac Vein

The iliac vein is approached retroperitoneally, but if ligation of both vessels is indicated, it is simpler and better to ligate the vena cava. The vessel is approached through a high McBurney type of muscle-splitting incision which is centered at the umbilicus The aponeurosis of the external oblique and the external muscle itself are divided in the direction of the fibers. The internal oblique muscle and the transversalis muscle are split and the peritoneum is exposed The dissection is car-

ried retroperitoneally and the peritoneum and its contents are retracted mesially with a large Deaver retractor. The vein is carefully isolated, and if it is technically possible, it is divided between clamps. The ends are then doubly ligated with two ligatures of 12 cotton. Because of technical difficulty, it is sometimes necessary simply to pass a ligature about the vessel with a ligature carrier and to ligate doubly the vessel in continuity. The incision is closed in layers with interrupted sutures of cotton or catgut.

Ligation of the Inferior Vena Cava and Ovarian Veins

This may be done retroperitoneally as in the division and ligation of the common iliac vein, but it can be done transperitoneally. This latter approach is advocated if the ovarian veins are to be divided and ligated at the same time. The retroperitoneal approach of the inferior vena cava is from the right side (Fig. 71).

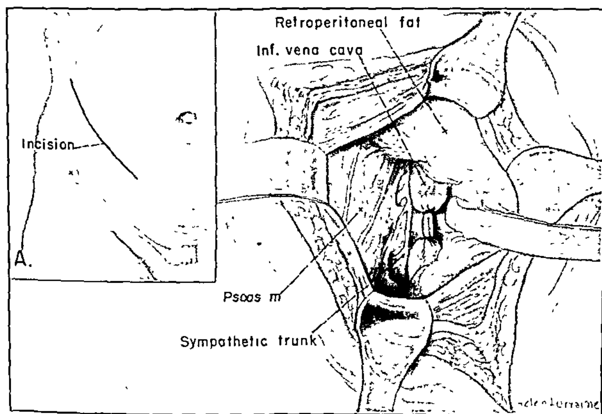


Fig. 71.—Retroperitoneal ligation of the inferior vena cava. The vessel is doubly ligated in continuity Inset *A* shows position of the incision

The vessel is ligated in continuity. It is carefully isolated and a heavy ligature, either of braided silk or a double ligature of 12 cotton, is passed around the vessel with a ligature carrier. The ligature is tied securely and a second ligature is placed about the vessel approximately 1 cm. away from the first ligature The incision is closed in layers with interrupted sutures of cotton or catgut. Ace bandages are applied to the extremities, and early ambulation is practiced. Some form of elastic support should be worn for a minimum of three months, and longer if there is any swelling of the extremity

The inferior vena cava may be exposed transperitoneally through a right paramedian incision. The peritoneum is divided lateral to the cecum and ascending

colon and the vena cava is exposed retroperitoneally. It is doubly ligated in continuity as previously described. The right ovarian vein is also identified and is divided and ligated at the level of the pelvic brim. If a clot is present in the vein, the ligation should take place above this point. Double ligatures of cotton are applied about the ends of the ovarian vein. The posterior peritoneum is resutured with a continuous suture of plain catgut. The posterior peritoneum on the left side is then divided lateral to the sigmoid colon, and the left ovarian vein is exposed retroperitoneally. It is divided and ligated as was done on the right with double ligatures of cotton. The posterior peritoneum is reapproximated with a continuous suture of plain catgut. The abdominal incision is closed in layers, as has been described elsewhere.

Chronic Thrombophlebitis

Chronic thrombophlebitis of the veins of the lower extremity is usually a great deal more disabling than varicose veins. In addition to chronic swelling of the part, there may be severe aching of the limb, stasis pigmentation and eczema, and ulceration. Linton has pointed out that these changes are secondary to increased venous pressure in the lower extremity as a result of damage to the venous system and their valves by the disease. It was stated earlier that lumbar sympathectomy might be indicated in those cases of chronic thrombophlebitic ulceration with vasospasm. As Linton has pointed out, lumbar sympathectomy is not necessary to cure a simple varicose ulcer. It may be necessary as an adjunct to therapy in chronic thrombophlebitic ulcers, particularly in those cases with marked hyperhidrosis Linton has advocated interruption of the superficial femoral vein and ablation of the superficial veins by stripping of the greater and lesser saphenous veins.

The rationale of dividing the superficial femoral vein as pointed out by Linton is to decrease the head of pressure which is exerted on the veins of the lower leg by the long column of unsupported blood Normally, the valves support the column in segments and thus decrease the venous pressure exerted on the skin and subcutaneous tissue Although the vein recanalizes after the acute condition, the valves are destroyed and a semirigid, toneless tube is left which acts more as a reservoir than a channel for the passage of blood.

The results with the Linton operation have not always been satisfactory. There is a general feeling of caution today in approaching the problem of chronic thrombophlebitis, particularly when complicated with ulcers. Many of the patients are going to have to learn to live with their legs It is probably wise to apply the therapeutic measures step by step. If therapeutic lumbar sympathetic blocks with procaine decrease the size of the leg, lumbar sympathectomy is indicated as the first step In case the results are unsatisfactory, the superficial veins are first stripped and the results are observed before a decision is made to employ deep vein interruption.

Interruption of Superficial Femoral Vein and Ablation of Superficial Veins—Linton Operation

A vertical incision is made in the upper thigh over the course of the femoral vessels, beginning at the point where Poupart's ligament crosses the vessels and extending downward for 15 cm. The saphenous vein is first divided and ligated at

the saphenofemoral junction along with all its branches, according to the technic previously described. The femoral sheath is then opened and the superficial femoral vein is carefully exposed. It lies mesially and somewhat posterior to the artery at this point. Because of previous reaction about it, it is usually thickened and adherent to the artery. After the profunda branch has been carefully identified, the superficial femoral vein is divided and ligated just distal to it. The division is made close to the profunda so as not to leave a blind pocket in which a thrombus might form. The ends of the vein are doubly ligated with two ligatures of 30 cotton. An intraluminal stripper is then inserted in the great saphenous and the vein is stripped from the ankle to the groin. Stripping is often difficult because of the scar tissue reaction about the vein in the lower leg. The patient is turned and the lesser saphenous vein is exposed in the popliteal space through a transverse incision. It is divided and the proximal end is ligated as previously described. The stripper is inserted and the trunk is stripped from the region of the external malleolus up. All incisions are closed with interrupted sutures of cotton. A resilient pressure dressing is applied from the toes to the groin. Penicillin therapy is given both pre- and postoperatively. The patient is ambulated early, but remains in the hospital until the sutures are removed on the seventh postoperative day. Elastic bandages should be worn for at least six months or longer after this operation. In some cases it is advisable for the patient to wear an elastic support indefinitely.

OBSTRUCTION OF LYMPHATICS OF EXTREMITIES

Chronic lymphedema of the extremities due to obstruction of the lymphatic channels in certain instances may be amenable to surgical therapy, although the results have not been too encouraging through the years. The types amenable to surgery fall into two groups: idiopathic and acquired Familial (Milroy's) lymphederma is the common example of the idiopathic group, while the acquired lymphedema is usually the result of accidental or surgical trauma which is often complicated by infection and, in the tropics, is a result of blockage of the lymphatics by *Filaria bancrofti.*

In the upper extremity chronic lymphedema most commonly occurs following radical mastectomy for carcinoma of the breast. Although the main lymphatic trunks are removed in the operation, collaterals usually develop and lymphedema is either transient or minimal in amount. If infection should intervene, adequate collaterals may not develop and chronic lymphedema remains permanent. In the lower extremity the most commonly seen type is Milroy's—familial lymphedema. Infection may be the factor in some cases The incidence of lymphedema has possibly been reduced in recent years as a result of control of infection by antibiotics.

Handley's Operation

None of the operations devised for the relief of lymphatic obstruction in the extremities has been entirely satisfactory. Handley first attempted to treat lymphatic obstruction of the extremities by introducing long silk threads in the subcutaneous tissue of the extremity, then across the area of obstruction (axilla or groin) to the subcutaneous tissue of the trunk. He hoped in this way to stimulate the development of collateral channels (Figs. 72 and 73). The results were not permanent and the operation is now chiefly of historic interest. In the light of our present

knowledge one would hardly expect permanent success from such a procedure, for the fact that sufficient anastomotic channels had not formed following obstruction in the primary channels would indicate that some factor was present in the tissues which prevented their development. The introduction of foreign material, even as slightly irritating to the tissues as silk, cannot be expected to lead to the development of permanently patent lymph channels, as the production of scar tissue would almost certainly cause their obstruction. However, the Handley operation is of historic importance because it stressed the significance of lymphatic block in persistent edema of the extremities and also because it emphasized the necessity of establishing patent lymph channels across the obstructed zones.

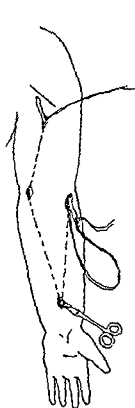


Fig. 72.

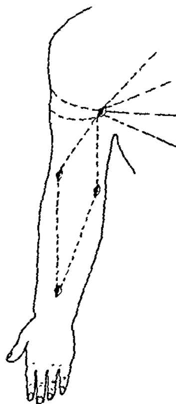


Fig. 73.

Fig. 72.—Placing of silk threads on anterior surface of arm and forearm to relieve swelling of the upper extremity. (Handley.)

Fig. 73.—Placing of silk threads on the posterior surface of the arm and forearm.

Gillies Pedicle Graft Operation

Gillies, Fraser, and McIndoe have attempted to solve the problem by grafting a bridge of full thickness skin across the blocked area. It is necessary that the transplanted skin contain lymphatic channels with valves which will direct the lymph flow in the proper direction. In a case with lymphatic obstruction in the groin they obtained a suitable block of skin from the arm and transferred it to the upper thigh, groin, and trunk. The operation was done in several stages and apparently was successful. This very ingenious procedure is based on careful anatomic studies and will no doubt lead to the development of a simpler means of relieving lymphedema of the extremities when the main channels are obstructed in the axilla or groin Rienhoff has used a pedicled graft from the latissimus dorsi muscle to bridge the axilla in patients subjected to radical mastectomy, with the purpose of

preventing lymphedema of the arm. As the last stage of the operation before skin closure, he cuts a fan-shaped area, which includes the subscapular nerve, artery, and vein, from the latissimus dorsi muscle. The free edge of the muscle is used to form the upper margin of the graft, and the flap is turned across the axilla and fixed by sutures to the remainder of the pectoral muscle and to the intercostal muscles. Rienhoff suggests that muscle grafts may be of value in the treatment of lymphedema, but this has not been determined.

Kondoleon Operation

The operation devised by Kondoleon is based on the assumption (supported by considerable clinical evidence) that in certain cases of lymphedema of the extremities the deep lymphatic channels are patent, while the superficial channels and the communications between the superficial and deep channels are obstructed. This obstruction apparently occurs at the level of the deep fascia, which is unusually dense in such cases. Excision of wide areas of this fascia is the most important step in the Kondoleon operation. Statistics indicate that approximately 50 per cent of the patients subjected to this operation obtain satisfactory results. It is likely that a better selection of cases would result in a higher percentage of cures. Sistrunk obtained decided improvement in about 75 per cent of the patients on whom he performed this operation.

Pratt and Wright, by further extension of the Kondoleon principle, achieved better results, according to their reports. Poth and his associates devised a procedure achieving essentially the same final result as the procedure used by Pratt and Wright, but by a different technic.

The preoperative preparation for the classical Kondoleon or one of the modifications is most important. The extremity is elevated for from one to two weeks to allow the swelling to subside Infection of the skin is carefully controlled. Prior to surgery the skin is carefully cleaned with soap and water and alcohol.

The technic of the Kondoleon operation is simple, but a wide area of tissue is exposed, so that unless care is exercised in controlling hemorrhage it is apt to produce shock. In case of lymphatic obstruction of the upper extremity, an elliptical incision is made on the posterolateral aspect of the arm extending from the wrist to a few centimeters below the shoulder (Figs. 74 and 75), sufficient skin being left to permit closure without tension Somewhat less skin should be excised opposite joints than elsewhere so that there will be no danger of limiting their motion. The skin is retracted and the incision is carried down to the deep fascia. An elliptical area, which includes an increasing amount of each tissue plane from without inward, including the fascia, is removed, bleeding is carefully controlled, and the skin is approximated If this does not give a satisfactory result, the procedure may be carried out on the anteromedial side of the limb a few weeks later. A similar procedure may be used when the lower extremity is involved (Figs. 76 and 77).

In the Pratt and Wright modification, the skin is undermined until three-fourths of the circumference of the leg is exposed. The superficial tissue and deep fascia over this three-fourths of the leg is then excised en masse. Bleeding is carefully controlled and the skin edges are reapproximated. If skin becomes devitalized, it is excised and split skin grafts are applied or the areas are covered by broad-based pedicle tube grafts.

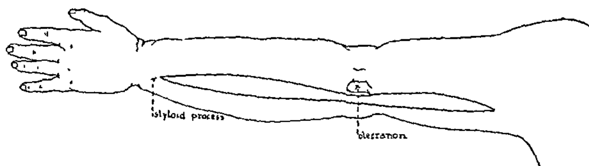


Fig. 74.—Lines of incision for operation of Kondoleon along the posterolateral surface of the upper extremity.

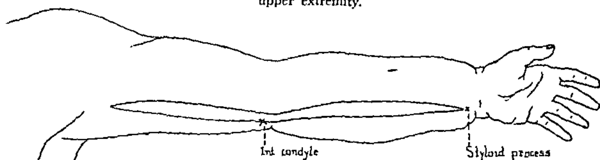


Fig. 75.—Lines of incision for operation of Kondoleon along the anteromedial surface of the upper extremity.

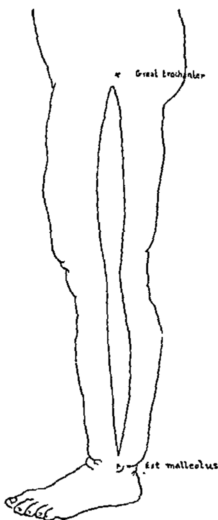


Fig 76

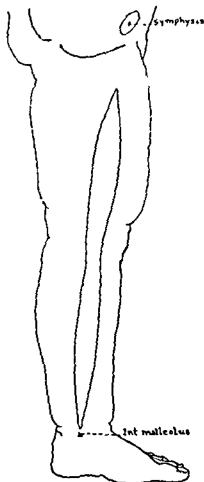


Fig 77.

Fig 76 —Lines of incision for operation of Kondoleon on lateral surface of the lower extremity

Fig 77 —Lines of incision for operation of Kondoleon on medial surface of the lower extremity.

In the operation devised by Poth and his associates, split skin grafts are removed from the entire circumference of the extremity except for a narrow strip over the anterior surface of the tibia. The remaining tissues down to the muscles except for the narrow strip over the tibia are excised. The muscles are then covered with the split skin grafts previously removed. At a second stage the subcutaneous tissue and fascia are removed from beneath the narrow strip over the anterior surface of the tibia.

Postoperatively, the legs are elevated for at least three weeks and elastic bandages are worn for months and sometimes even indefinitely. These operations are extensive and justified only in the moderately advanced or advanced cases.

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CHAPTER 12

DUPUYTREN'S CONTRACTURE; INFECTIONS OF THE HAND AND FOREARM

BENJAMIN W. RAWLES, JR.

DUPUYTREN'S CONTRACTURE OF THE HAND

Since Dupuytren's contracture involves the palmar fascia primarily and the adjacent skin secondarily, operations should be directed toward the division or preferably the excision of the contracted portion of these structures. Most surgeons now adopt open excision of the thickened palmar fascia with a considerable margin of normal fascia and the hopelessly involved skin with primary closure of the wound as the treatment of choice. A. A. Davis, one of the few recent writers to take exception to this view, advocates multiple subcutaneous division of the fascia, especially in laborers. He suggests that it will frequently be necessary to repeat the procedure but believes this is justifiable because of the poor results obtained by the more radical operations. In the group of thirty-one cases he studied, only 38 per cent of those subjected to open excision of the palmar fascia obtained a perfect result, while 75 per cent of those treated by multiple subcutaneous division of the fascia obtained a satisfactory result.

These results are not in agreement with those published by Kanavel, Koch, and Mason, J. S. Davis and Finesilver, and others Kanavel and his associates reported good results in 69 per cent of their cases subjected to the more radical procedures. While J S. Davis and Finesilver do not give definite figures as to their results, they strongly advise the open operation and urge as complete excision of the palmar fascia as possible. They do suggest, however, that multiple subcutaneous division of the fascia should be used in cases where the more extensive procedures are inadvisable. Both Koch and J. S. Davis advise excision of all grossly involved skin and the use of whole thickness skin grafts when necessary for primary closure.

Excision of Palmar Fascia

This procedure is carried out under general anesthesia. A tourniquet is used since a bloodless field is so essential to the meticulous dissection. All of the affected palmar fascia and the extensions into the deep palm and into the fingers must be removed Incisions, as far as possible, are placed in flexion creases. One incision is made along the distal flexion crease in the palm and one along the flexion crease of the thumb The skin is carefully dissected away from the underlying fascia until the fascia is completely exposed. The dissection is begun at the base of the palm and is carried distally, care being taken not to injure the distal vessels or nerves.

The septa running deep in the palm are divided as deeply as possible, and the affected fascia extending into the fingers is all carefully dissected out. This may require an incision along the lateral aspect of the proximal pad with an L-shaped extension across the proximal interphalangeal flexion crease. Absolute hemostasis is essential after removal of the tourniquet. Some of the skin may be so calloused that it has to be removed, or parts of it may become nonviable as the result of dissection from the underlying tissues so that it has to be cut away. These defects are covered with full thickness skin grafts. The skin edges are carefully approximated with cotton or silk sutures and a resilient pressure dressing is applied with the hand in extension. Physiotherapy is begun as soon as healing will permit.

Multiple Subcutaneous Fascial Division

Multiple subcutaneous division of the palmar fascia is performed by inserting a small-bladed, sharp tenotomy knife beneath the skin at the ulnar border of the hand and passing it between the skin and the thickened fascia; then, while the involved fingers are extended, the knife blade is turned toward the fascia and that tense fibrous structure is divided. The operation has the same objections as all other blind procedures; namely, the danger of injuring adjacent structures, especially vessels, nerves, and tendons. It is also considered to be inadequate for most cases.

INFECTIONS OF THE HAND AND FOREARM

Because of the close anatomic relationship between the hand and forearm, infections of these areas should be considered together The palmar synovial sheaths of the flexor tendons (radial and ulnar bursae) extend from the hand into the forearm, deep to the transverse carpal ligament. When distended with pus these bursae are apt to rupture at their proximal ends into the major fascial space of the forearm. Lymphatic infections of the forearm also are usually secondary to infections of the hand.

So far as treatment is concerned, there are two chief types of infection of the hand and forearm: that which gives rise to lymphangitis and cellulitis and is to be treated conservatively, and that which tends to localize and form pus and therefore requires surgical intervention. These types may be further divided into those infections which, because of the anatomic structures involved, are characteristic of the location, as infection of the flexor tendon sheaths; and those similar to infections in other parts of the body, as furuncles and carbuncles. The latter are treated in much the same manner as elsewhere in the body and therefore call for no detailed discussion other than to emphasize the necessity for care in incising such infected areas, especially on the fingers, because of the proximity of important underlying structures.

Since the anatomy of the hand and forearm is complex, it is necessary to have a detailed knowledge of it before one can hope to understand the manner of development, routes of extension, and methods of treatment of infections in this area. Surgeons who are called upon to treat such infections should familiarize themselves with the anatomy and pathology of this region by reading the excellent monographs on this subject by Kanavel, Auchincloss, Hart Bunnell, and Brickel. Satisfactory treatment of infections of the hand and forearm requires, first, recognition of the spaces involved and, second, the institution of adequate drainage through a properly placed incision.

A few minor infections of the fingers may be operated upon either without an anesthetic or with regional anesthesia, but as a rule it is better to use general anesthesia for drainage of infections of the hand and forearm. A tourniquet may be very helpful in providing a bloodless field for incision and drainage and is mandatory for drainage of tendon sheaths.

Eponychia and Paronychia

Eponychia and paronychia usually result from trivial injuries along the nail border and, if properly treated in the beginning, are readily cured. A considerable number develop from infected hangnails and improper methods of manicure. If hangnails are treated by the application of a mild antiseptic at the onset of the inflammation, the vast majority of them will clear up promptly. If they are somewhat more advanced, they can usually be cured by applying wet dressings of about 50 per cent alcohol for a few hours; but if the infection has developed to the point of forming a small purulent blister lateral to the nail, the roof of the blister should be excised and a hot wet dressing applied. If the infection has extended beneath the border of the nail, adequate drainage may be obtained by pushing the cuticle back; but if it involves the root of the nail, that portion of the nail which has become separated from the matrix should be excised. In more advanced cases of subungual infection, it may be necessary to make an incision at the lateral border of the nail, extending to the posterior portion of the sulcus. An incision should never be made over the root matrix as this may result in injury to it which will be followed by a cleft nail. After the lateral incision is made, the eponychium is pushed back to expose the base of the nail and the depths of the sulcus, all of the detached nail is excised, and a small piece of petrolatum gauze is inserted beneath the soft tissue flap. In very advanced cases it may be necessary to make bilateral incisions to elevate the entire eponychium. It should be emphasized, however, that it is rarely necessary to make an incision if the infection is treated properly in the early stages. If it is neglected and allowed to go on to a chronic subungual abscess, the distal phalanx may become involved and this may eventually necessitate its removal.

Anterior Closed Space Infections or Felons

Infection in the anterior closed space of the distal phalanx is often the result of pricking the finger with a needle or pin. The infection thus introduced within the dense fibrous wall of this space develops in the looser tissues and causes a marked degree of tension. The arteries supplying the diaphysis pass through the anterior closed space on their way to the bone, and, therefore, when increased tension develops, the blood supply to the bone may be cut off and a sequestrum formed. It is essential, therefore, that infections in this region be drained before the blood supply to the bone is impaired. The diagnosis of felon in the early stages is not difficult because of the severe throbbing pain associated with induration and tenderness of the palmar surface of the distal phalanx.

Not infrequently these infections are treated by a longitudinal midline incision, but this is undesirable. Since the fibrous trabeculae are perpendicular to the surface, it does not give adequate drainage. It also leaves a scar which interferes seriously with the sensation of the palmar surface of the distal phalanx. In early infections an incision should be made, extending from a short distance distal to the

distal flexion crease of the finger along the anterolateral border of the finger to near the tip, the so-called "hockey stick" incision (Fig. 78). In this way the trabeculae are divided and drainage is improved. The side on which this incision is to be made can usually be determined by careful palpation of the distal phalanx. If

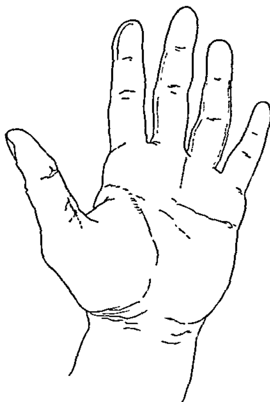


Fig. 78.—Hockey stick incision for drainage of anterior closed space infection, lateral incisions for drainage of flexor tendon sheaths, and incisions for drainage of proximal portion of flexor tendon sheaths and lumbrical spaces. (Kanavel)

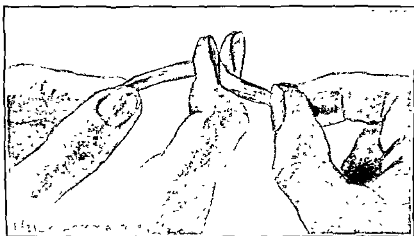


Fig 79—Method of Dorrance for incision of felon. This incision should be reserved for the more advanced cases.

the process is advanced, it is probably best to follow Dorrance's suggestion to make a horseshoe-shaped incision extending from a short distance distal to the distal flexion crease on one side around the tip of the finger to the same position on the opposite side. The fibrous trabeculae are divided near the palmar surface of the bone and a small piece of silk or rubber tissue is inserted to prevent too rapid heal-

ing (Fig. 79). This incision gives excellent drainage but leaves a rather extensive scar, and its use should therefore be reserved for more advanced cases. It is important not to begin the incision too near the flexion crease so that injury to the terminal portion of the tendon sheath will be avoided; and the incision should not be placed too far toward the dorsal surface of the finger, as the blood vessels supplying the phalanx may be injured.

Collar Button Abscesses of the Palm

Individuals with thick calluses in the palm of the hand are liable to develop infection beneath these areas which may result in the so-called collar button type of abscess Infection beneath the callus forms a relatively superficial abscess, but the dense overlying tissue may cause the pus to burrow into the deeper tissues through the thin distal portion of the palmar fascia. It is extremely important, therefore, to excise the roof of the superficial abscess and inspect its floor carefully to determine whether there is a small sinus connecting with a deeper abscess. If there are suspicious areas in the floor of the abscess, they should be examined with a small probe, and if a collar button type of abscess is found, it should be given adequate drainage, if necessary, by dividing completely the web space. This, fortunately, heals readily and does not give any appreciable disability.

Infections of the Tendon Sheaths

Infections of the dorsal tendon sheaths are relatively infrequent and less serious than when the flexor tendon sheaths are infected. Extensor tendon sheath infections are best treated by a simple longitudinal incision. This gives adequate drainage and is usually followed by a rapid clearing up of the infection.

It is absolutely essential that surgeons treating infections of the hand have a clear understanding of the anatomy of the flexor tendon sheaths (Fig. 80). Those of the index, middle, and ring fingers extend from approximately the level of the distal flexion crease of the finger to a point about 2.5 cm. proximal to the base of the finger. In most cases there is no connection between these sheaths and either the radial or ulnar bursa, but the tendon sheath of the ring finger may communicate with the ulnar bursa. When the sheaths become distended with pus, they are apt to rupture into the deep fascial spaces of the hand. Infection in the sheath of the index finger ruptures into the thenar space, and infection in the sheath of the ring finger into the middle palmar space. While infection in the middle finger sheath may open into either of these spaces, it usually ruptures into the middle palmar space The sheath of the flexor pollicis longus tendon is continuous with the radial bursa which extends deep to the transverse carpal ligament, and the sheath of the flexor tendons of the little finger is usually continuous with the ulnar bursa which also extends deep to the transverse carpal ligament into the forearm. There is not infrequently a communication between these bursae so that infection in one will spread to the other and also to the major fascial space of the forearm unless early adequate treatment is given The major fascial space lies between the flexor digitorum profundus tendons and the pronator quadratus muscle distally, and the flexor digitorum profundus tendons and the interosseous membrane proximally. It is obvious, therefore, that infection in either the radial or ulnar bursa is likely to lead to

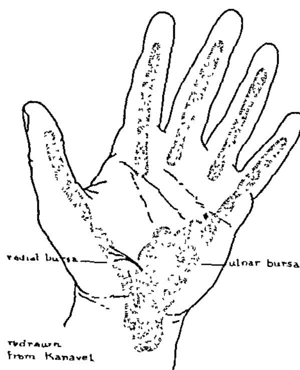


Fig. 80.—Outline of flexor tendon sheaths and radial and ulnar bursae. (Kanavel.)

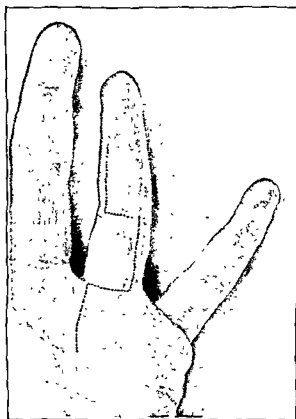


Fig 81.—Line of incision which may be used for drainage of severe infection of the flexor tendon sheaths of the index, middle, or ring fingers.

infection in the other bursa and also in the major fascial spaces of the forearm unless adequate drainage is given early.

Several incisions have been devised for drainage of the flexor tendon sheaths of the three middle fingers. These sheaths are sometimes opened by a single long midline incision, but this should not be done as it leads to a dense scar on the palmar surface which gradually contracts and interferes with the extension of the finger as well as with palmar sensation. Kanavel advocated either single or double anterolateral incisions, the unilateral incision in early cases and the double incision only in more advanced cases (Fig 78). He also advised that the tendon sheath be opened laterally. Auchincloss advises lateral incisions with small cross incisions at the level of the flexion creases, and opens the tendon sheath in the midline.

The following incision has been used with considerable satisfaction for infection of the tendon sheaths of the three middle fingers (Fig. 81). It begins at the distal flexion crease of the finger at a point on one side anterior to the digital vessels to avoid injury to the blood supply to the finger; it is carried proximally to the middle flexion crease of the finger, along the middle flexion crease to a corresponding point on the opposite side, then to the proximal flexion crease, along the proximal flexion crease to that side of the finger on which the incision began; and finally it is carried up on the palm for a distance of about 2.5 cm. The incision is carried through the skin and subcutaneous tissue and the flaps are dissected over nearly to the midline, thus exposing the tendon sheath, which, if grossly involved, is incised in or near the midline. In less advanced infections two lateral incisions are made in the sheath, leaving a small bridge at the site of the middle flexion crease to prevent prolapse of the tendon. This incision gives excellent drainage and the blood supply to the flaps is good. If the skin flaps become displaced later they may have to be freed and sutured in position to prevent a disfiguring scar. Because of this possibility, it is probably best to reserve this incision for late cases.

If there is evidence of infection in the lumbrical spaces, they should be opened through that portion of the incision used to drain the palmar portion of the tendon sheath. If there is greater tenderness over one lumbrical space, the incision should be made so that the palmar extension lies over that side.

It is better not to use any form of drainage material, but if it is felt that this is essential, a thin strip of silk or rubber tissue may be used. If drainage material is not used, it will probably be necessary to keep the incision open by gently separating the wound edges with a hemostat at each dressing.

It is extremely important to use a careful aseptic technic during the operation and at subsequent dressings, as these infections are usually due to streptococci, and if staphylococci are introduced there is a much greater tendency for pockets to form and thereby prolong the infection. Active motion should be started as soon as possible after drainage has been established, and both active and passive motion should be carried out until there is a complete return of function (Figs 82 and 83), or until no further improvement is apparent.

Infection of the flexor tendon sheath of the little finger is drained through the same type of incision on the finger as is used in the other flexor tendon sheaths, and, if the ulnar bursa is involved, the incision is carried proximally along the radial side of the hypothenar eminence to a point near the transverse carpal ligament If the entire ulnar bursa is involved, an additional incision should begin about 3 cm.

proximal to the styloid process of the ulna over the lateral portion of its volar surface, extending proximally for 7 cm. This incision is carried through the skin and subcutaneous tissue, the muscular attachments to the ulna are divided, and the tissues are dissected away from the volar surface of the ulnar as far toward the midline of the forearm as the ulnar bursa. This procedure will usually suffice, but if the bursa has not ruptured into the fascial space of the forearm, it should be opened by a hemostat. In advanced infection or if there is very marked swelling, it may be wise to extend the palmar incision through the transverse carpal ligament, completely dividing it. This gives better drainage and releases the pressure on the structures behind the ligament. The latter procedure, however, should be



Fig 82



Fig. 83.

Figs 82 and 83 —Photographs showing an almost complete return of function six weeks after drainage of an early suppurative tenosynovitis of the flexor tendon sheath of the ring finger

reserved for unusual cases. If the bursa has already ruptured into the forearm and if the infection has obviously extended upward, Kanavel advised a second incision in the forearm about midway between the wrist and elbow, a short distance in front of the ulna, to expose the junction between the flexor carpi ulnaris and the flexor digitorum sublimis muscles These muscles are separated with care not to injure the ulnar artery, and drainage is instituted

When the middle palmar space is involved secondary to infection of the flexor sheath of the little finger without extension to the ulnar bursa, an incision is made

over the adjacent lumbrical space, a hemostat is passed posterior to the tendon sheaths, and the middle palmar space is drained. If the ulnar bursa is also involved, the hemostat may be passed through the wall of the bursa and into the infected midpalmar space.

To avoid spread to the ulnar bursa or to the major fascial space of the forearm, infection in the sheath of the flexor pollicis longus tendon should be given adequate drainage as soon as the diagnosis is made. The incision begins anterolaterally at the distal flexion crease of the thumb and is carried proximally along the ulnar side of the thenar eminence to within 3 cm. of the transverse carpal ligament. Kanavel showed that it is unwise to extend the incision nearer the transverse carpal ligament than this, as there is danger of injuring the motor branch of the median nerve to the thenar muscles.

If the entire flexor pollicis longus sheath and radial bursa are obviously involved, drainage should be instituted proximal to the transverse carpal ligament. This may be done either through an incision on the radial side or through the incision used for draining the infection of the proximal portion of the ulnar bursa. Infections in either bursa are apt to lead to rupture into the fascial space in the forearm. If the bursa has not ruptured, it may be opened by a hemostat, as suggested in infections of the ulnar bursa.

Infections in the Deep Fascial Spaces of the Hand

Infection in the dorsal subaponeurotic space of the hand is best treated by longitudinal incision between the extensor tendons which overlie the dorsal surface of the metacarpal bones. Only one longitudinal incision is usually necessary to drain this space adequately, but this incision should extend throughout practically the entire length of the space.

The two most important fascial spaces in the palm of the hand are the thenar and the middle palmar spaces (Fig. 84). As already stated, infection in these spaces may result from infection in the flexor tendon sheaths, especially those of the three middle fingers Infection in the thenar space is best treated by an incision along the palmar border of the radial side of the metacarpal bone of the index finger (Fig. 85). The incision is carried through the skin, subcutaneous tissue, and fascia. A hemostat is inserted and directed immediately anterior to the palmar surface of the metacarpal bone and slightly proximally into the thenar space, then opened and withdrawn, releasing the pus. If necessary, a small strip of rubber tissue is inserted for drainage. The middle palmar space is drained through a transverse incision placed in the distal flexion crease of the hand (Fig 86). The infection lies beneath the flexor tendons to the middle and ring fingers. A hemostat is carefully inserted into the space between the tendons and drainage is established. It is usually best to insert a small rubber tissue drain In opening either of these spaces, it is important not to carry the instrument beyond the midline of the metacarpal bone of the middle finger, as the septum between the thenar and midpalmar spaces may be penetrated.

Human Bite Infections of the Hand

Among the most serious infections of the hand are those due to human bite. Under this general term are grouped all lacerations of the tissues by human teeth regardless of the manner in which the injury is received Such injuries naturally

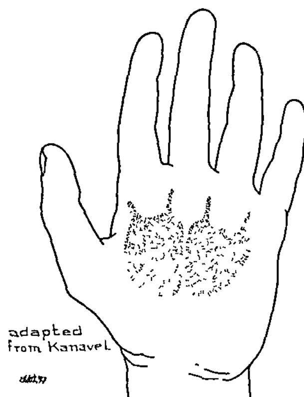


Fig. 84 —Outline of the middle palmar and thenar spaces. (Kanavel)

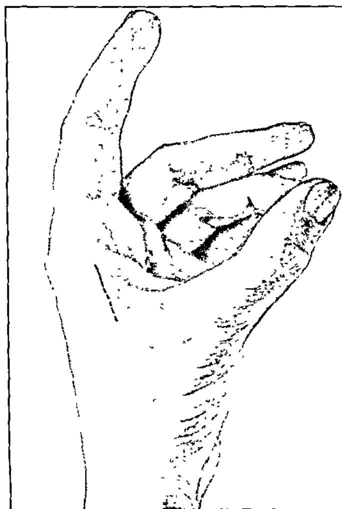


Fig. 85.—Line of incision for drainage of thenar space. (Kanavel) (Redrawn by Helen Lorraine.)

occur to any part of the body, but the hand is affected more frequently than other areas. The part most frequently involved is the dorsal aspect of the metacarpophalangeal joints of the right hand. Injury to this area usually results from a blow with the closed fist against the upper incisor teeth. This combination of circumstances partially explains the seriousness of the injury, for the doubled fist produces tension over the knuckles including the extensor tendons, and the tissues are therefore easily divided. Not infrequently both the extensor tendon and the capsule of the joint are penetrated, and the tendon is usually contaminated even when it is not divided. When the fingers are extended, the tendon moves proximally and thus contaminates the tissues proximal to the opening. This has an important bearing on the immediate treatment of such a case.

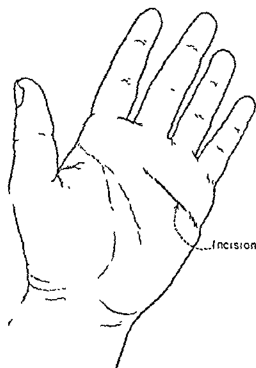


Fig. 86.—Line of incision for drainage of middle palmar space

The organisms in the mouth are usually highly virulent aerobes and anaerobes and when deposited in such areas as the joints or cellular tissue, away from the wound of entrance, may give rise to extremely serious infections. Infection also usually occurs in the subaponeurotic space of the dorsum of the hand and in the subfascial space of the proximal phalanax. Infection may spread to one or more of the important structures and spaces of the hand, the route depending upon the tissues involved in the original injury. It may spread distally beneath the digital fascia and eventually involve the phalanx, or it may extend around the finger to enter the lumbrical canals. Proximal extension along the lumbrical canals will involve the deep fascial spaces of the palm. It is important for the surgeon who treats such cases to bear in mind these routes for spread of the infection, so that involvement of any particular structure or space will be noted early

Immediate treatment of human bites is most important. The superficial part of the wound should be enlarged and a careful examination made to determine which structures are wounded. If the tendon is injured, an incision should be made

which will expose it and the adjacent tissues for a short distance, 1 to 1.5 cm., proximal to the wound. All badly injured tissue should be excised and the wound should be thoroughly irrigated with warm normal saline solution. Sutures should not be used, even in the tendons. The hand and forearm are put at rest on a palmar splint and the patient is confined to bed, preferably in a hospital where the hand can be watched closely. The subsequent treatment will naturally depend upon whether the wound becomes infected and upon the routes by which the infection spreads.

Postoperative Principles in Hand and Forearm Infections

The hand and wrist are placed in a splint in the position of optimum function and a large sterile dressing is applied. The dressing is kept soaked with warm boric acid or magnesium sulfate solution and heat is maintained with hot-water bottles. Antibiotic therapy is instituted. The dressing is changed in twenty-four hours under strict aseptic technic to determine whether or not adequate drainage has been provided and whether or not there has been spread of infection to other spaces. The drains are removed in forty-eight to seventy-two hours and the wet dressings are discontinued as soon as possible to prevent unnecessary maceration of skin. Physiotherapy is begun as soon as healing will permit.

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CHAPTER 13

WOUNDS OF SOFT TISSUES; CARBUNCLES; PILONIDAL CYSTS AND SINUSES; TUMORS, BENIGN AND MALIGNANT; MELANOMA

HARRY J. WARTHEN, JR.

WOUNDS OF SOFT TISSUES

Wounds of the soft parts incurred under peacetime conditions frequently are not treated with the care which they deserve. The introduction of antibiotics and sulfonamides has not been an unmixed blessing, for some surgeons have relied upon the general effects of these agents to compensate for shortcomings in the local treatment of the condition.

The extent of the injury and the causative agent determine in large measure the type of treatment. Wounds made by sharp objects, in general, respond to simple cleansing and closure, whereas injuries caused by blunt force require careful excision of devitalized tissue, in addition to the measures mentioned above.

The type of anesthetic used will depend upon the age and general condition of the patient as well as the extent of the injury and the likelihood of infection.

In a clean-cut and limited wound of recent origin, a local anesthetic carries minimal danger of spreading infection and avoids the hazard and associated inconveniences of a general anesthetic. While the anesthetic may be injected at a distance, a more painless method and one of especial value in the treatment of injuries in childhood is to insert the solution beneath the margins of the laceration into the subcutaneous tissues about the circumference of the wound. This method is of less value in the more massive injuries and should not be attempted where extensive excision and repair of deep tissues are necessary. Local anesthesia, of course, should not be used in definitely contaminated wounds or those which by reason of the duration of the injury are thought to be infected.

In wounds received shortly before admission to the hospital the area about the injury should be thoroughly cleansed with soap and water, followed by careful shaving of the involved region The shaving should not only provide for a clean operative field but should also permit the proper attachment of the dressing without placing adhesive tape over a hairy area. A sterile gauze sponge, lightly packed in the laceration, will prevent further contamination of the wound and will check troublesome oozing of blood during the cleanup Ether or benzene will remove grease and dry the skin surfaces. A second gauze sponge may then be substituted for the first, and the surrounding skin surfaces are painted with half-strength tincture of iodine or other suitable antiseptic followed by appropriate sterile draping. If local anesthesia is used, it should be injected at this stage of the procedure. The wound is flushed out by large amounts of normal saline solution. Ether is a suitable cleansing agent if damaged subcutaneous tissue and fat are present. Strong antiseptics must, of course, be avoided. The depths of the wound are explored

The treatment of injuries to underlying tendons or bone is discussed in the chapters on orthopedic surgery. All foreign bodies are carefully sought and removed. Devitalized tissue must be excised and all bleeding points ligated with fine catgut. Care is taken to avoid strangulation of adjacent tissue. Reid used fine silk for ligatures and sutures in injuries of this type, but nonabsorbable suture material should be confined to only the cleanest incision, and the refinements of technic inherent in the use of this type of material must not be abridged.

Fine suture material should be used, care being taken not to place too many buried sutures. The skin margins are loosely approximated with interrupted silk sutures. A pressure dressing should be applied to obliterate dead space and to check any capillary ooze. If the injured part is near a joint, a properly applied splint will promote healing and allay pain.

A prophylactic injection of tetanus antitoxin should be given whenever the conditions under which the injury occurred make tetanus a possibility. The patient should always be skin-tested for sensitivity before the antitoxin is given. The possibility of previous immunization by tetanus toxoid injections must be kept in mind, for the administration of a booster dose of toxoid is far safer than a prophylactic injection of antitoxin. Injuries involving muscle which are contaminated by soil, and especially those occurring in the South Atlantic and Gulf states where gas gangrene is more common, should receive the appropriate antitoxin. Here also a skin test is essential. Antibiotics should be used as an adjunct but never as a substitute for proper local treatment.

CARBUNCLES

Despite the advances made in recent years in the treatment of infection, the prevention and cure of carbuncles has not been altered to any great degree. It is true that early infections situated on the back of the neck or dorsum of the fingers may be aborted by the use of antibiotics, but once the diagnosis of a carbuncle is made, the likelihood is that the infected area will have to be treated surgically just as it was in the past before the introduction of antibiotics

Lee and Downs' method of crucial incisions made with a sharp knife, extending well beyond the indurated area and dividing the involved tissue into four sections, is still the surgical method of choice Each of the four flaps is undermined about halfway between the skin and the deep fascia to open all of the infected columns of fat in the carbuncle and thus permit the discharge of pus and release of tension from each focus of infection As each flap is elevated, strips of petrolatum gauze, or pads of dry gauze if oozing is free, are placed in the defect. Antibiotics are continued and warm dressings are applied for relief of pain and to facilitate the drainage of pus The gauze is removed within forty-eight hours and the triangles of skin are permitted to fall into the normal position. In small carbuncles it is sometimes possible and desirable to excise the entire involved area.

PILONIDAL CYSTS AND SINUSES

The proper treatment of pilonidal cysts and sinuses was one of the major surgical problems encountered during World War II. A survey conducted in the hospitals of the Army Air Forces in 1944 showed no less than thirteen different methods of treatment. In the larger hospitals entire wards were filled with patients

undergoing treatment for this disabling condition, and in some cases continuous hospitalization for more than a year was necessary in order to effect a cure.

Several conclusions were evident from this survey. The earlier these cases were seen and treated, the shorter the period of disability. The cysts which had been the site of only one abscess were naturally far easier to cure than those which had been acutely infected several times with resulting "sprinkling-pot pattern" of draining sinuses over the sacral region. The greatest deterrent to primary healing was the presence of infection at the time of definitive surgery. The failure to obliterate dead space was a frequent cause of poor healing, and cursory aftercare resulted in many recurrences. Few conditions require the detailed pre- and postoperative care that must be exercised in treating pilonidal cysts.

All infection must be carefully cleaned up before operation is carried out. This means that every abscess and involved sinus must be opened widely. Sitz baths and antibiotics will speed up this phase of the treatment, but several weeks should elapse between the last evidence of local infection and the actual excision of the involved tissue. The best operation for this condition is the simplest. Excision and closure are preferable to more elaborate procedures with extensive undercutting and shifting of flaps.

Larsen in 1947 presented an excellent review of the various types of procedure advocated in the treatment of this condition, with the immediate and late results obtained by each method. In a series of 225 consecutive cases he obtained initial healing in 96.9 per cent following simple excision and primary closure.

The technic, in brief, is as follows: All infection is thoroughly cleared up as outlined above. The patient is placed in the prone position, the operating table is broken in order to flex the thighs moderately on the body, and the buttocks are strapped apart. The operative site is thoroughly cleansed with green soap, ether, and an appropriate antiseptic. Care is taken to prevent contamination of the operative field by the anus. Methylene blue or some similar dye may be injected in a sinus to stain the various tracts but this is not necessary and may be misleading. An elliptical block of tissue is outlined in such a manner that the sites of former draining sinuses and the usual dimple or sinus in the lower midline are incorporated with the excised skin. As a rule, it is not necessary to remove an excessive amount of tissue. If one sinus is at a considerable distance from the other sinuses and is situated far laterally, an extension to this point may be made at right angles to the long axis of the ellipse and the major portion of the intervening skin need not be removed. This will permit coring out the connecting sinus without needless sacrifice of skin and subcutaneous tissue

Only normal tissue should be divided, and if a former tract is encountered in the dissection this must be incorporated in the tissue to be removed by a wider excision. The margins of the wound should be vertical or directed inward and not slanted downward and outward. The dissection is carried downward to the sacrococcygeal fascia. Bleeding vessels are ligated with fine cotton, silk, or plain catgut, and hemostasis must be complete The incision is flushed out thoroughly with normal saline solution. The adhesive straps are removed, and the incision is then closed in successive layers with fine suture material as indicated above The sacrococcygeal fascia is included in the deep sutures. The depth of the incision determines the number of layers necessary, for dead space must not be left (Fig. 87).

By placing sutures one row at a time before tying, it is possible to approximate widely separated tissues without undue tension on any individual suture if the but-

tocks are pressed together while each series of sutures is tied. The skin is closed by relatively superficial on-end mattress sutures of cotton or silk. A snug pressure dressing with mechanic's waste is applied. If the postoperative course is favorable and afebrile, the incision should not be dressed for seven or eight days, at which time the sutures may be removed. Healing is promoted by keeping the patient relatively quiet during this period. Activity not only disturbs the incision but increases local sweating with resulting maceration. The bowels should not be moved for several days. Antibiotics should be given in adequate doses during the period of healing. Care must be taken that there is no overlap of the skin margins, and hairs which bridge the incision and tend to grow into the opposite skin margin must be removed, otherwise a recurrence is likely.

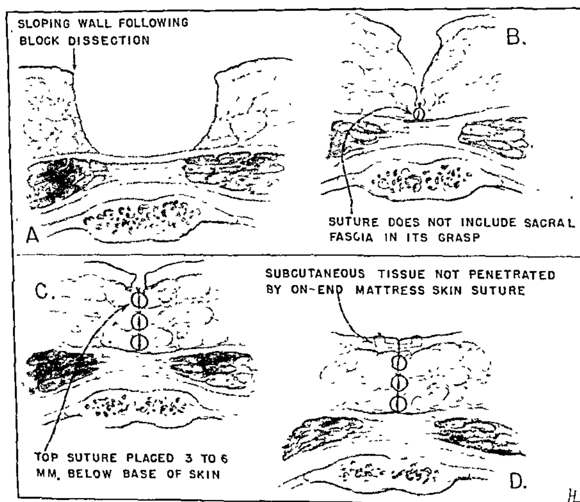


Fig 87.—Simple excision and primary closure of tissue about site of a pilonidal cyst or sinus. (After Larsen.)

The foregoing procedure gives excellent results in pilonidal cysts of small or moderate size In neglected cases with numerous sinuses involving a large area, it may be impossible to obtain primary approximation of the skin margins without undue tension with resulting necrosis and separation.

The partial closure method described by MacFee. Mutschmann, and others is of aid in handling these large cysts, and the preoperative treatment is carried out as described previously. Every effort should be made to clean up all infection prior to operation as in the case of primary closure. At operation all diseased skin and subcutaneous tissue is excised. It may be necessary to undercut the skin in the

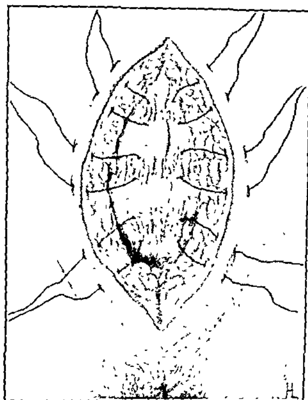


Fig 88.—Type of excision required to incorporate all tracts and sinuses in an extensive pilonidal sinus. No effort is made to approximate the margins of the wound, which instead are sutured to the underlying sacrococcygeal fascia (After Mutschmann.)

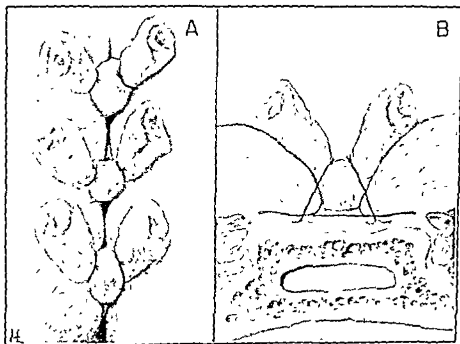


Fig 89.—Method of partial closure of wound following excision of pilonidal sinus. The sutures may be tied over gauze sponges or threaded through buttons. (After Mutschmann.)

more extensive cases and remove considerable subcutaneous tissue and fat. This does not carry the disadvantage in the partial closure method that it does in the complete closure procedure In fact, a moderate excision of the subcutaneous fat may facilitate the suture of the skin margins to the deeper structures. (Figs. 88 and 89.)

The incision is flushed out with normal salt solution after careful ligation of all bleeding points. The partial closure is effected by suturing the skin edges to the sacrococcygeal fascia with interrupted silk or cotton. The skin margins are brought as close to the midline as possible without tension. An ellipse of fascia of varying width remains exposed. This area is soon covered by epithelium which grows in from the skin margins This method requires frequent dressings and close postoperative care. The end result is not perfect anatomically, for the crease between the buttocks is accentuated and carried higher than normal The ultimate function, however, is good and the recurrence rate is not high

TUMORS, BENIGN AND MALIGNANT

There is little question as to the proper treatment of benign tumors arising from the skin or tissues immediately beneath this structure. Sebaceous cysts and lipomas should be excised. Warty growths may be fulgurated. Pigmented tumors must be handled with care and excised with sufficient margin to preclude the possibility of a local recurrence if the nevus proves to be malignant. Microscopic examination should be made whenever there is any question as to the type of tumor or the slightest possibility of a malignancy being present. Bleeding points should be ligated with fine catgut or nonabsorbable material, and the skin should be approximated carefully with fine silk or cotton.

The treatment of malignant skin tumors presents an entirely different problem and requires an altogether different approach. The most frequent distinction that should be made lies between basal and squamous cell tumors. A procedure which should prove adequate in treating a basal cell tumor may be insufficient to cure a squamous cell epithelioma. A biopsy should be done to determine the type of tumor. If the lesion is small and so situated that removal of the entire growth with a wide margin is possible, this should be done in preference to excision of a small segment of the tumor. If the growth is extensive and located near important structures, a biopsy of the margin of the ulcer incorporating the junction of the tumor with normal adjacent skin should be carried out. A local anesthetic injected at a distance is satisfactory. The electrosurgical unit may be used to diminish bleeding and possibly minimize the likelihood of spread of tumor cells.

The type of tumor found on microscopic examination will determine the subsequent treatment If the cells arose from the basal layer and a wide excision has already been carried out, no further treatment will be needed in many cases. If the original tumor was extensive and only a segment was removed for diagnosis, a decision must be made as to whether radical surgery followed by skin grafting or intensive radiation should be used Both modes of treatment are usually effective in basal cell tumors. If cartilage or bone is involved in the growth, radical excision will be necessary to effect a cure. Fortunately this type of tumor rarely metastasizes to the regional lymph nodes and these need not be excised.

If a pedicle flap is needed, this may be outlined at the time of excision of the tumor and transferred in about ten days. Pedicle flaps serve a twofold purpose in

the treatment of basal cell tumors. These grafts not only facilitate the closure of large defects but also, when brought from another area, have a degree of immunity which delays or possibly prevents local recurrence in some cases of incomplete removal of the primary tumor.

If the biopsy shows squamous cell tumor, a more drastic procedure is necessary. In these cases the part of the body involved will determine to a greater degree the type of treatment to be used. Epithelioma of the lips and buccal mucosa are discussed elsewhere. In tumors on the face a wide surgical excision followed when necessary by a pedicle repair and usually by a block dissection of the appropriate cervical lymph node is the procedure of choice in favorable cases.

When feasible, the primary tumor and the regional lymph nodes should be removed en masse, as advocated by Halsted in the radical cure of carcinoma of the breast. In regions other than the breast this may not be possible.

If the tumor is of a low degree of malignancy with good differentiation and many "pearls," a wide local excision may suffice. If because of the type of tumor or the early removal of the initial growth the regional lymph nodes are allowed to remain, the patient must be kept under close observation in order that an immediate block dissection may be carried out if there is evidence of recurrence in the lymph nodes. In any type of squamous cell tumor except the most benign, a radical block dissection must be done as soon as possible after excision of the primary tumor. The trend in recent years has been to do more radical procedures in the treatment of advanced malignancies. The ultimate worth of the more extensive and mutilating operations must await a longer period of evaluation.

MALIGNANT MELANOMAS

All deeply pigmented nevi and all moles which by reason of their location are subject to trauma should be excised as a prophylactic measure.

Suspicious nevi which appear in childhood should be removed, for pigmented tumors which are excised prior to puberty do not recur.

Certain precautions must be observed in the prophylactic excision of pigmented tumors. The nevus must not be traumatized in any manner during the procedure. On theoretical grounds, intravenous Pentothal Sodium should be the anesthetic of choice, but, if the patient demurs, a carefully administered local anesthetic probably carries a minimum of risk. The hypodermic needle must be inserted at a distance and the procaine should be injected around and not into the region of the tumor. The nevus must not be grasped by an instrument or manipulated in any manner. A sharp scalpel should be used and the nevus must not be coagulated A margin of 1 cm. should be given the tumor and the full thickness of the skin must be excised. A pathologic examination should be made, for any tumor worth removing is worth examining microscopically If the microscopic examination should show a malignant melanoma, a second and more radical procedure must be done.

If the patient gives a history of pigmentation of the nevus or recent increased elevation, scaliness, bleeding, or itching, a much wider margin should be given than the 1 cm. described above, for these changes should arouse suspicion of malignant change.

A certain number, fortunately small, will show unmistakable indications of malignancy when first seen. These are usually coal black, fungating, or ulcerated tumors. Adjacent areas of stippling or actual daughter tumors about the primary lesion may be seen. If the tumor is growing very rapidly, the metastases may not show the intensity of pigmentation which is present in the initial lesion. Enlargement of the regional lymph nodes indicates widespread involvement and a correspondingly poor outlook. An x-ray of the chest should be made to rule out blood-borne metastases to the lungs.

If the lungs are uninvolved and the patient shows microscopic or unmistakable clinical evidence of a melanoma being present, a major excision is indicated. A general anesthesia must be administered. The primary tumor must be excised with a minimum of 5 to 10 cm. of adjacent skin. Skin grafting is frequently necessary. The underlying fat and fascia should be removed over an even greater area. If the regional lymph nodes are grossly involved, a block dissection of these glands should be made ten or fourteen days later. This interval of time is permitted to elapse in order to allow tumor cells which may be migrating up the lymphatics at the time of the first operation to reach the lymph nodes before these nodes are excised. If the lymph nodes are not involved clinically at the time of excision of the melanoma, the block dissection of the regional nodes should be deferred until five or six weeks after the initial operation.

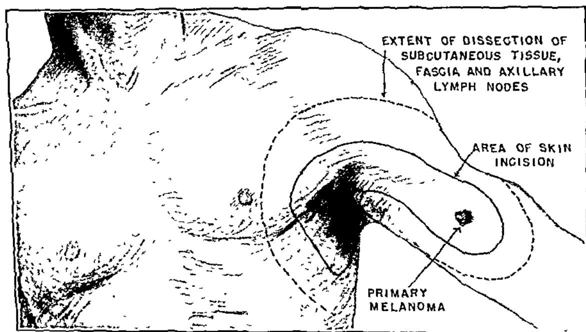


Fig 90—Method of excision and dissection in continuity which may be used when the primary lesion is situated relatively near the lymph nodes into which the lymphatics drain. (Pack.)

In recent years, Pack and his associates at the Memorial Hospital have been carrying out in suitable cases an "excision and dissection in continuity" for primary and metastatic melanomas of the skin. This procedure is based on the principles outlined by Halsted in treating carcinoma of the breast. Halsted's operation entailed removal in one mass of the primary tumor, the adjacent skin, the lymphatics through which the tumor cells would pass, and the lymph nodes into which these lymphatics drained. By applying these same principles, Pack is able, in suitably

situated melanomas, to remove widely the primary tumor as well as the lymphatics and lymph nodes with a large segment of skin, subcutaneous fat, and underlying fascia (Fig. 90).

If a melanoma arises on a finger or toe, the accepted treatment has been to amputate the digit and follow this by a wide dissection of the axilla or groin. This, of course, does not obviate the danger of implants at any level in the extremity as a result of tumor cells lodging in the lymphatics.

In an effort to overcome this hazard, the Memorial Hospital group has carried out more drastic procedures during the past few years. In cases where the primary lesion is situated too distant from the regional nodes to permit "excision and dissection in continuity," interscapulothoracic (shoulder-girdle) amputations have been performed for melanomas of the upper extremity. In the lower extremity, melanomas of the foot with metastases to the femoral and inguinal glands have been treated by disarticulations of the hip joint with retroperitoneal dissection of the iliac and obturator lymph nodes Hemipelvectomies (hindquarter amputations) have been performed which entailed amputation of the lower extremity together with the innominate bone on the involved side. It may be found that operations of this magnitude are not only justified, but indicated, in what would otherwise be a lethal condition, though sufficient cases have not been followed over an adequate period to permit final conclusions at the present time. A procedure as mutilating and disabling as a shoulder-girdle amputation or hemipelvectomy should be buttressed by an impressive five-year-cure rate before its general adoption is justified.

Many melanomas have been treated by radiation but the results have been uniformly discouraging. The only hope of effecting a cure at the present time is early and definitive surgery.

The fate of the patient with an early melanoma rests in the hands of the first physician who sees him. Temporizing with such a condition or ill-advised methods of removal make the death of the victim inevitable

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CHAPTER 14

GENERAL PRINCIPLES OF PLASTIC SURGERY

HARRY J. WARTHEN, JR.

SCOPE OF PLASTIC SURGERY

Plastic surgery has made great progress during the past decade. The large number of wounded of World War II who presented problems in plastic surgery resulted in a better understanding and standardization of treatment than has been true in the past.

Plastic or reconstructive surgery deals with the correction of defects resulting from trauma, disease, or errors of development. While in a broad sense the term may be applied to operations on any kind of tissue, as bones, tendons, or nerves, it usually refers to the correction of defects involving the skin or mucosa either entirely or in large part. Plastic surgery formerly was concerned chiefly with the face, though now any portion of the body in which there are defects from injury or illness or from developmental defects may be the site of a plastic procedure.

Among these conditions are wounds of various types, particularly burns produced by thermal, electrical, or chemical injuries as well as x-ray and radium burns; scars and keloids; chronic ulcers; congenital deformities as harelip, cleft palate, syndactylism, malformation of external ear; nevi, hemangiomas, lymphangiomas; crushing injuries involving facial bones; reconstruction of the breast, external ear, nose, eyelids, cheeks, lips; defects of scalp, neck, trunk, and the extremities.

GENERAL PRINCIPLES

The principles of plastic operations involve, first of all, the nutrition of the corrected tissue, and, second, the mechanical reconstruction that will bring the parts as nearly as possible to a normal condition. Operations that apply to particular regions will be discussed in the chapters devoted to regional surgery. There are, however, many underlying principles which must be borne in mind if success is achieved, regardless of what portion of the body is involved.

Plastic operations are of two types: that in which the margins of the wound are prepared for a fresh union and sutured without transplanting tissue or without the intervention of flaps, and that in which flaps or grafts, free or pedunculated, are necessary. The former type is applicable in harelip and cleft palate or in defects which follow a small or narrow injury. Usually after burns or extensive

traumas the resulting deformity is so great that it is impossible to reconstruct the tissues by excision of the affected part and union of the edges of the wound. In such cases recourse may be had to several procedures. One is to undermine the margins of the wound for a considerable distance and determine if the additional relaxation obtained by the undermining will permit approximation of the edges of the wound.

Davis secured excellent results by gradual partial excision of small scar tissue areas and certain nevi. This method is also of value in the removal of tattooed areas. If the area is too broad for total excision and approximation of the edges of the wound, an elliptical segment is excised from the center, the margins of the wound are undermined, and the edges of the wound are approximated. The size of the ellipse should be limited only by the ability to close the margins. After this has healed firmly and the adjacent skin has stretched, which requires from six to twelve months, another section of the area is excised. In this way the elasticity of the skin will permit ultimate approximation of the healthy portion of the skin in a linear scar by gradual traction, which would be impossible if all of the involved tissue were excised at once. In these cases in which the defect or deformity is too great to permit closure by multiple excisions, some form of flaps or grafting must be employed. Multiple excisions should not be used to remove deeply pigmented nevi. *These should always be excised with a good margin and an incision should* not be made into the tumor.

The operation to be performed depends largely upon the part of the body affected and also upon the function of this region. If, for instance, there is a large raw surface on the back of the legs where a scar will not be conspicuous or annoying, the chief problem is to heal the raw surface even if there results a marked scar. It is always desirable, of course, to have as little scar tissue and as nearly a normal skin as possible. If, however, a large defect on the body or limbs can be so healed as to give the patient a stable scar without discomfort or interference with function, the main indication will have been fulfilled and prolonged and complicated operations to render the scar less prominent will hardly be justifiable.

Methods that not only restore function but remove deformity as well are to be desired. Whole skin, as a free graft or with a pedicle flap, usually gives the best results from every standpoint The graft should match the texture of the skin around the defect as far as possible As a rule, skin taken from the region of the deformity more nearly corresponds to the texture of the skin about the defect than that taken from some distant part Sometimes, however, it is impossible to obtain flaps near the defect and they must be transplanted from a distance.

When the appearance of the scar is of secondary importance and the healing of the wound is the main object, thin grafts of epidermis in sheets or cut into small seed implants, small deep grafts, or "postage stamp" grafts are very satisfactory When properly applied on a clean field, such grafts usually take without difficulty, and large raw surfaces that would require months to epithelize or would perhaps never heal are closed in ten days to a few weeks. These grafts would be universally used instead of free transplants of whole skin or flaps except for two disadvantages: the scar resulting is conspicuous, for the skin of the scar does not appear to be normal, and there is often a marked tendency to contraction after their use. The

contraction after an injury to the skin of the face, for example, is not in epithelial elements of the skin but in connective tissue that underlies the epithelium. In other words, the contraction lies in what corresponds to the corium, which is composed largely of connective tissue and on which rests the epithelial layer. If, in the healing process, this is made up of scar tissue, particularly of the dense scar tissue that follows a burn, contraction deformity will probably result even though the surface may be covered by healthy epithelium. It is contraction in this subepithelial layer that produces the striking deformities following burns of the face or hands.

If, then, a scar contraction is excised and thin grafts of epidermis are used to heal over the surface, the contraction will almost invariably recur. In order to avoid this, it is necessary to use thick split or full thickness grafts which include not only the epidermis but normal healthy corium that does not contract.

The general health of a patient who requires plastic surgery is of utmost importance Before any major plastic procedure, a complete history should be taken and a complete physical examination made, as well as the customary laboratory work including serology, urinalysis, hemoglobin determination, serum protein, red and white blood cell counts, blood smear, differential counts, prothrombin and clotting time. Other special laboratory work may be suggested by the history or physical examination. Such conditions as hypoproteinemia, secondary anemia, syphilis, active otitis media, or any other acute infection, malnutrition, or blood dyscrasias are definite contraindications to an immediate plastic operation, particularly in children. Before operation ample opportunity should be given for scar tissue to contract, and its blood supply should be improved by exercises and massage. Many operations followed by poor results may be avoided if these conditions are recognized. Time will be gained in the end by improving a poor surgical risk through every available means.

Asepsis, gentle surgery, proper pressure dressings, immobilization, and detailed postoperative care are all important factors. If antibiotics are used and the patient's general health is good, with normal tissues and the defect so situated that it may not readily become contaminated, infection rarely occurs. In certain locations, as about the mouth, anus, and perineum, infections are occasionally unavoidable. Concentrated compound tincture of benzoin applied over fresh incisions, especially about the lips, nose, face, and mouth, lessens contamination and also acts as a splint. Collodion may be used in the same manner after removal of sutures. Tissues that have a poor blood supply due to extensive undermining, tension, or scar tissue are more prone than normal tissue to infection. Hematomas invite infection. If infection does develop, the usual methods of combating it in other types of surgery should be carried out: namely, antibiotics, improvement of the general resistance of the patient, drainage of accumulations of pus with or without irrigation of the cavity, early removal of infected sutures, and hot wet dressings The addition of about 20 per cent glycerin to the usual solutions for hot wet dressings (saturated boric acid, strong magnesium sulfate, normal physiologic up to 2 per cent sodium chloride) is valuable, as it does not produce maceration of the skin, allows ample drainage, and tends to diminish excessive granulation tissue. Cod liver oil, 5 to 10 per cent balsam of Peru in castor oil, and scarlet red ointment are effective in stimulating healing after the acute infectious process has subsided.

Pyocyaneus infections occur frequently and are treated by wet dressings of 0.5 to 2 per cent acetic acid changed frequently and continued over a period of twenty-four to seventy-two hours. A Murphy drip containing dilute acetic acid is a convenient way of controlling pyocyaneus infections. It is felt by some that an acid media merely decolorizes the characteristic blue-green color of the drainage. Be that as it may, the drainage lessens and appears less significant after the use of acetic acid. The more severe superficial infections such as the now rare erysipelas and those associated with streptococcus, lymphangitis, and cellulitis quickly respond to appropriate antibiotics. If sloughing occurs, the dead tissue should be cut away as soon as a definite line of demarcation has formed. Hydrogen peroxide facilitates the cleansing of infected and sloughing surfaces and, diluted with equal parts of water, is also a very good mouthwash after operations within the oral cavity.

A point that cannot be stressed too much is the control of hemorrhage. Blood clots beneath a graft often will cause all or a large portion of it to die and will, in addition, invite infection. Hemorrhage occurring at the time of operation is controlled by *clamping and twisting small vessels and by ligating larger vessels with* very fine catgut. Oozing surfaces are checked by firm pressure with hot saline compresses. Sometimes a useful procedure is to coagulate the bleeding point with the electrosurgical unit, but the coagulated area must be minimal. As a hemostatic agent Adrenalin should be used with caution because of the possibility of secondary bleeding. Topical thrombin is of value in the presence of persistent oozing. As far as practical, ligatures and any other means of controlling bleeding which produce additional foreign bodies or an increased tissue reaction are to be avoided in the bed of a wound that is to receive free skin grafts. Whenever ligatures are necessary, very fine silk or 0000 plain catgut is the ligature of choice. A properly applied sea sponge or mechanic's waste dressing immobilized by an elastic bandage will produce uniform pressure over the entire area and will largely prevent oozing beneath grafts and undermined wound margins. Secondary hemorrhage is treated by *exposing, clamping and ligating the bleeding vessel, removing the blood clots,* cleansing the wound with normal saline solution or a mild antiseptic, and reapplying a pressure dressing. Hematomas that develop from oozing should be opened, the clots removed, and the wound cleansed and redressed. For persistent post-operative bleeding not controlled by the above measures, general treatment for prolonged bleeding must be used. The administration of calcium, vitamin C, vitamin K, and other possible deficiency factors seem more effective. When these measures fail, transfusions of whole blood or certainly recently drawn blood are indicated.

The principal factors in preventing large deforming scars are gentle handling and complete relaxation of tissues, prevention of infection and hematomas, clean *incisions made at right angles to the surface of the skin*, careful suturing tending to slight eversion of the skin edges, immobilization of dressings with even and proper pressure (as by mechanic's waste) so applied as to produce no tension on the wound edges, the use of elastic bandages, early removal of stitches, as well as other pains-taking details

Incisions should be made parallel to Langer's lines of cleavage of the skin (Figs. 91-93). An appreciation of the constancy of these lines of tension is emphasized by the early Byzantine Christian mosaics recently discovered in Istanbul and

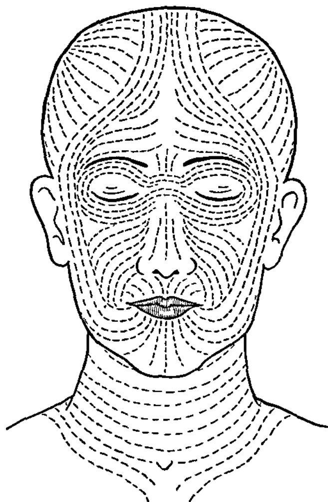


Fig 91.—Langer's lines of tension of the skin of the face. (Redrawn from Pick)

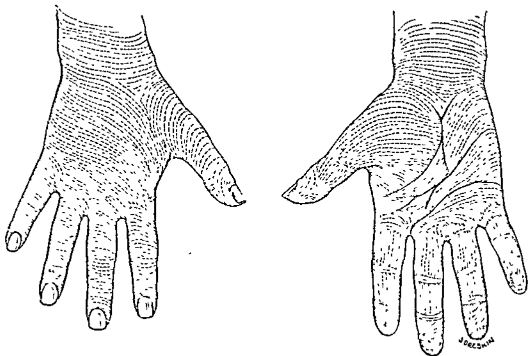


Fig. 92.—Langer's lines of tension of the surface of the hand. (Pick.)

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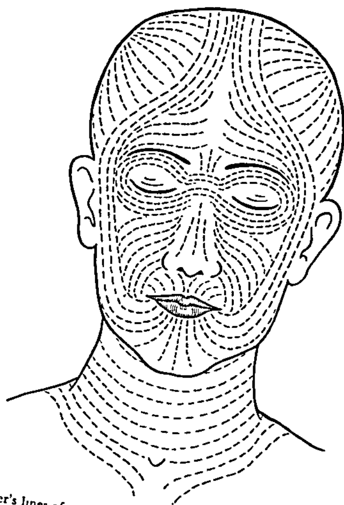


Fig 91 —Langer's lines of tension of the skin of the face. (Redrawn from Pick)

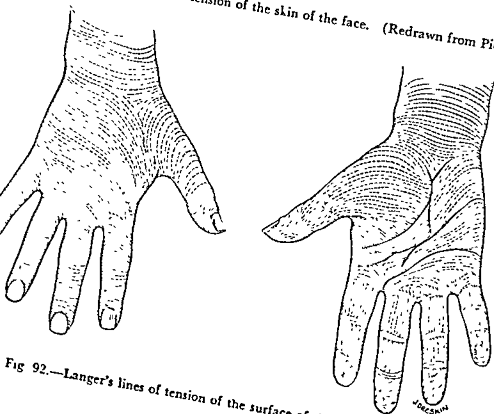


Fig 92.—Langer's lines of tension of the surface of the hand. (Pick.)

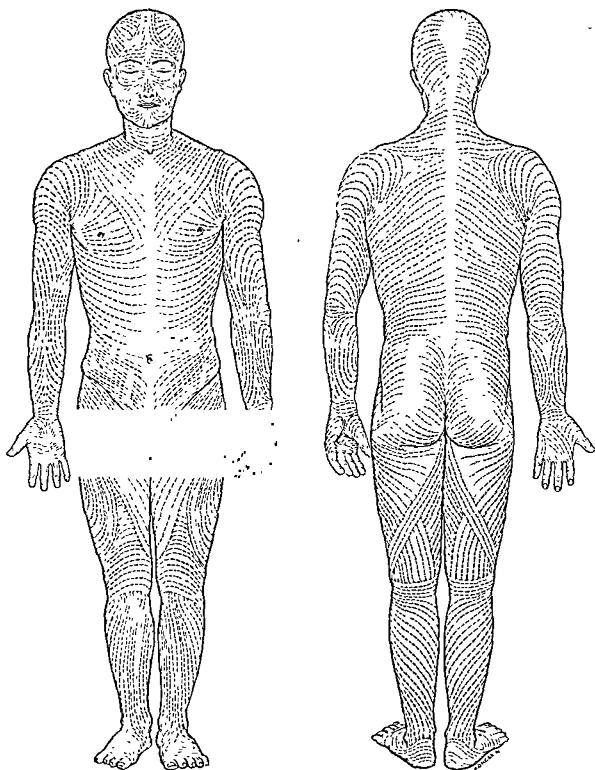


Fig. 93.—Langer's lines of tension of the skin of the trunk, head, and extremities. (Pick.)

photographed by Kessell. The general course of the connective tissue bundles of the corium determines the direction of these linear clefts. If the incisions follow these tension lines, there will be little gaping of the wound or spreading of the subsequent scar. If the incisions are made across these lines, wide gaping will occur and a broad scar will result. The intelligent use of radium and the roentgen ray is often very helpful in preventing hypertrophied scars and keloids in patients who are known to be subject to these disfigurements.

Skin grafting is one of the most important procedures in plastic surgery. Grafts taken from another of the same species may seem to flourish at first but usually slough off or are absorbed in the course of time. Grafts usually live when taken from the patient's own body. Grafting from one individual to another rarely proves successful.

Trusler and Cogswell state that, from their experience and a critical survey of the literature, they are led to believe that most reports of success with homotransplants of skin arise from the fact that these grafts can and often do adhere and appear to grow for several weeks. In their cases, however, such grafts have not remained viable and their ultimate fate has been a more or less delayed slough. Healing by scar tissue formation eventually occurred. These observations are in agreement with reports of Longmire and others. Padgett believed that autotransplantation of skin usually succeeds and that syngenesiotransplantation of skin is theoretically improbable except in identical twins where it is theoretically probable and clinically has occurred. He has reported a successful growth of skin transplants from one identical twin to another. Converse and Duchet reported a similar case. Experimental work upon animals and theoretical reasoning argue against the blood grouping of an individual playing a role of any essential significance in the homotransplantation of skin. The simultaneous use of cortisone does not aid in the use of homografts.

PLANNING OPERATIONS

Photographs, models, cases, drawings, and accurate measurements of cases are of great value as records for later comparison and likewise are helpful in planning the best operative procedure. They also may be invaluable from a medicolegal standpoint. A flexible metal rule, calipers, lead foil, patterning material such as perforated cellosilk or cellophane, and a means of outlining incisions are indispensable. One of the various antiseptic dyes (as 5 per cent brilliant green in an alcoholic solution) on a sterile applicator stick, or a fine drawing pen can be used to mark out prospective incisions.

ANESTHESIA IN PLASTIC SURGERY

A considerable number of the less extensive plastic operations can be done under local anesthesia, using a 1 per cent procaine solution to which has been added 2 to 4 drops of 1:1,000 Adrenalin chloride solution to each 30 c.c. of the procaine solution. Definite contraindications to local anesthesia are lack of cooperation by the patient, as with infants and children, interference with the accuracy of operation by the distortion of the tissues, and impaired circulation from the edema produced by the infiltration.

As a rule, the anesthesia indicated in plastic surgery on adults corresponds to that used in general surgery. A greater degree of selection is necessary in carrying out plastic procedures on children.

The basic principles of good anesthesia are the same regardless of the type of surgical procedure indicated, and these include:

I. Preoperative evaluation of the patient
 a. Activity
 b. Drug idiosyncrasies
 c. Anesthesia preferences
 d. History of previous anesthesia
 e. Physical examination
 f. Laboratory work
 g. Weight

II. Preoperative medication
 a. Evening sedation
 b. Preoperative sedative
  1. Barbiturate
  2. Narcotic
  3. Autonomic blocking agents—atropine, scopolamine
 c. Rectal Pentothal

III. Choice of anesthesia

IV. Control of airway
 a. Anoxia
 b. Carbon dioxide elimination
 c. Finger-tip control of plane of anesthesia

V. Control of heat loss or retention

VI. Shock
 a. Blood
 b Intravenous fluids

Regional or general anesthesia may be used as the situation demands. Surgery of the head and neck presents major problems in plastic cases. The basic principles of anesthesia described above are best carried out by endotracheal anesthesia with the Stephen's nonrebreathing, nonresisting valve in children for surgery involving the face, neck, and oral cavity. This avoids the more usual, but less physiologic, open drop ether and insufflation ether technics. Many of the principles and technics outlined above are discussed in greater detail in later chapters.

Preoperative medication is most important; if properly administered, it will avoid psychic trauma that otherwise may scar the personality for years, and it will allow for ease in future handling of the patient. The basal metabolic rate is lowered, fear is allayed, induction is made easy, the secretions are reduced, and reflexes are blocked. The fear of anesthesia which many adults have today frequently dates back to an unpleasant experience in childhood. In children, it is seldom

necessary to give a hypnotic the night prior to operation; however, if it is desired, one of the quicker acting barbiturates may be used.

In children under 50 pounds of body weight, Pentothal Sodium may be given rectally. Atropine in the desired dosage is given forty-five minutes preoperatively. The dosage is 20 mg. (0.2 c.c.) of a 10 per cent solution per pound of body weight given thirty minutes before operation. A No. 16 urethral catheter is lubricated and inserted 5 cm. within the rectum. The buttocks are taped together. After the desired dosage is given, the catheter is cleared with 2 c.c. of air and clamped. Leaving the catheter taped in place prevents the child from expelling the medication The child falls asleep within five to fifteen minutes. This is only a basal hypnotic, and a supplemental anesthetic must be given to secure anesthesia.

Once the child is asleep, the anesthetist must assume protective control of the patient. For safe anesthesia, an absolutely patent and secure airway is mandatory. This is best obtained by the use of an endotracheal tube. Because of the frequent objections raised to the intubation of children, this technic will be discussed. Walker feels that the complications of this procedure are due to faulty technic rather than to the intubation itself.

A child should be intubated in the lower second plane of anesthesia with a nonirritating plastic endotracheal tube. Although some anesthetists advise that a water-soluble anesthetic jelly be used on the tube, no lubricant is actually necessary. In order to assure that the tube is the correct size, it must be selected only after the larynx has been exposed. To accomplish an atraumatic intubation, the tube is inserted with a twisting motion. Once the tube is in place, it should be checked to ascertain that it is not in too far. In children the trachea is short and the tube can easily be passed into the right main bronchus. The lungs are checked to see if they inflate easily; if they do not, the tube is withdrawn until easy inflation occurs. The tube is then fastened securely in place in such a manner as to avoid distortion of the mouth and to be accessible to the anesthetist. With the exception of the endotracheal tube, the anesthetist may then remove himself and his equipment from the operative field. He must, however, remain in position to watch and control the patient's respiration.

Extubation is equally as important as intubation. "Bucking on the tube" (coughing with the larynx open) should be avoided Unless secretions are present, endotracheal suction should not be done. Secretions should be removed from the pharynx and nasopharynx and the child should be well oxygenated. Upon expiration, the tube is quickly removed and oxygen is given by mask. Adherence to this technic will avoid the possibility of laryngeal edema.

Ether, cyclopropane, and Pentothal Sodium are all good anesthetic agents in children; however, the most physiologic method and the one involving the least cumbersome apparatus is a nonrebreathing, nonresisting technic. Stephen's valve, a more recent modification of the Leigh valve, is an improvement over the earlier Ayre method. A child cannot handle the regular circle filter anesthesia machine because of the high resistance; the patient works hard, soon builds up a carbon dioxide excess, and becomes exhausted. The Waters to-and-fro cannister is cumbersome, must be changed frequently so that the child will not build up heat, and there is the danger of inhaling dust.

Stephen's valve has a minimal resistance and its outlet is attached directly to the endotracheal tube Consequently, the anatomical dead space is reduced by half. A two-liter bag is connected to the valve. A direct flow of gases, usually 6 liters of nitrous oxide to 2 liters of oxygen, enters the bag. With this system the patient receives sufficient oxygen and the nitrous oxide reduces the amount of ether needed. If necessary, assisted or controlled respiration may be instituted by closing the expiration valve with the finger and rhythmically compressing the bag. The rapid flow of gases used, none of which are rebreathed, assures adequate carbon dioxide elimination. Finger-tip control of the plant of anesthesia is complete with the information gathered by holding the breathing bag. With this method, respiration and pulse are slower, and approach normal, whereas with open drop ether, they are both rapid. There is no excessive perspiration, the child's color remains good, and the "washed-out" appearance so frequently seen during long procedures under open drop or insufflation ether is absent.

The anesthesiologist must be ever watchful of the patient's circulatory status. Whenever deemed necessary, intravenous fluids should be started prior to operation. The gauge of the needle should be large enough to allow an easy flow of blood if a supplemental transfusion should become necessary The child's blood volume may be roughly judged at 40 c.c per pound of body weight. In young children, what would be a relatively minor blood loss in an adult may be relatively large. To offset this, a small transfusion mav be necessary. Children frequently have a rapid pulse and respiration, and blood pressure determinations are unreliable. It is well to remember that one of the earliest recognizable signs of shock is coldness of the feet Early and adequate replacement of blood loss is mandatory to prevent respiratory embarrassment, circulatory collapse, and possible death

PREPARATION OF OPERATIVE FIELD

Preparation of the field for operation varies with the tissue to be repaired. The technic for skin cleansing is similar to that for any other surgical operation. A satisfactory method is to shave the skin and thoroughly wash it with green soap and water followed by the application of ether and then 70 per cent alcohol. This should be done a few hours before the operation, and the prepared area should be protected bv a sterile light gauze dressing or towel fixed with adhesive or a bandage well beyond the disinfected area Great care should be taken not to injure the skin by improper shaving with a dull razor, by roughness, or any other means. Just before the operation the field may be painted with a 3 per cent tincture of iodine solution which is allowed to dry, after which the iodine is largely removed by 70 per cent alcohol On the face and neck as well as the genitalia, iodine is often irritating, and, if used there, it should be thoroughly removed with alcohol Tincture of Metaphen or Merthiolate is very effective and in recent years has largely supplanted iodine in operations on the face, neck, or on patients who are known to be sensitive to iodine Regardless of the antiseptic used, it is advisable to decolorize the stain by the use of 70 per cent alcohol.

It is inadvisable and even dangerous to use strong antiseptics on mucous membranes. It is better to cleanse mucous membranes by irrigating with a large quan-

tity of some mild antiseptic solution, following this with one of the so-called silver protein antiseptics. Thus, an eyelid is prepared for operation by frequent warm 2 per cent boric acid solution irrigations followed by 10 to 15 per cent Neo-Silvol or Argyrol. For operations within the mouth, cleansing of the teeth and gums with a toothbrush and frequent mouthwashes of a fresh sodium perborate solution or one-half strength hydrogen peroxide are advisable. Exceptions to this procedure occur in infants and young children with harelips and cleft palates where no special measures are employed before operation other than cleansing the entire face and neck with soap, water, and alcohol and following each feeding with a small amount of sterile water. The mucous membrane may be cleansed with 2 per cent boric acid solution. The judicious use of antibiotics postoperatively will diminish the likelihood of serious infection in these potentially contaminated areas. Mild antiseptic nose drops, such as 10 to 20 per cent Argyrol or Neo-Silvol are sometimes used postoperatively.

The preparation of a granulating area for operation is more difficult. Thorough irrigation of the granulations with boric acid solution or normal saline solution is probably as effective and certainly less irritating than stronger solutions. The area may be flushed with ether. The skin about the area should be carefully cleansed and treated with one of the stronger antiseptics before the operative field is draped. Instruments and gloves which have been in contact with the granulations should not be brought into a sterile operative field. It is advisable to have members of the surgical team assigned to specific operative fields so that infection will not be transmitted from infected to uninfected areas. Neutral zones may be designated where skin grafts, etc., may be placed to prevent infection from being spread.

INSTRUMENTS, NEEDLES, AND SUTURES

Few special instruments are necessary if the surgeon is accustomed to using small hemostatic forceps, light retractors, and other instruments which are required for accurate and gentle surgery. To avoid undue trauma, wound margins, skin flaps and practically all soft tissues should be handled with small hooks (Guthrie eye fixation hooks) The Bard-Parker knife with handle No 3 and blade No. 10 and the sharp-pointed blade No 11 are suitable for most plastic operations. Where circulation in the margins of a wound or in the distal part of a pedicle flap is poor, as evidenced by cyanosis from tension, the sharp-pointed No 11 blade is indispensable in making small puncture incisions to relieve tension and diminish venous stasis. For undermining wound margins and for intraoral work, the curved blade No. 12 and handle No 7 are very satisfactory, and for fine work blade No. 15 is suitable. Some of the special instruments needed in such operations as cleft plate repair, split and full thickness grafts, will be mentioned in the description of these operations. For buried sutures No 000 or No. 0000 plain catgut is satisfactory, though fine silk or cotton may be used where there is little possibility of infection or subsequent drainage. For suturing the skin and mucous membrane one of the finer nonabsorbable suture materials is preferable For tension sutures, silkworm-gut, nylon, and occasionally No. 30 rustless steel or silver wire serve well. Where tension is present, as in suturing a wound from which a pedicle flap has been removed, it is advisable to tie

the suture material over rubber tubing, soft metal plates or buttons in order to prevent a line of pressure necrosis. In general, the best needle is a small, curved (or half-curved), cutting-edge needle. One of the methods of suturing is illustrated (Figs. 94 and 95). No suture should be tied tightly enough to cause blanching or other evidence of strangulation of the tissues. A certain amount of tissue reaction with swelling follows any operation, and allowance must be made for this The early removal (two to four days) of sutures in operations about the face is imperative in order to prevent suture marks and to obtain the best cosmetic result. The application of flamed adhesive strapping or flexible collodion will tend to prevent spreading of the incision after removal of the sutures.

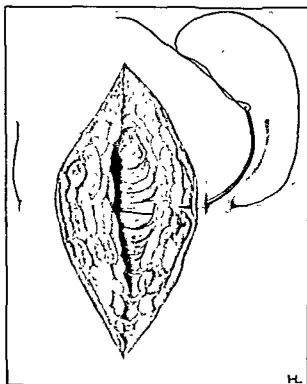


Fig 94

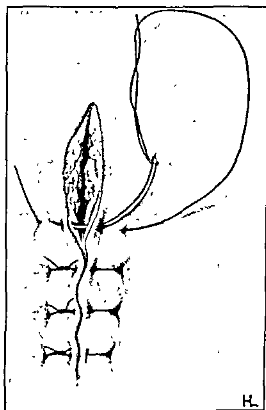


Fig. 95.

Figs. 94 and 95.—McMillen on-end mattress suture.

DRAINS AND DRESSINGS

Careful hemostasis largely obviates drainage, though in some instances drains must be inserted to prevent hematoma formation. Small strips of rubber dam may be placed beneath pedicle flaps and removed in two or three days

Suture material may be attached to the drain, which can then be withdrawn by making traction on the long end of the suture previously carried to the margin of the dressing This permits removal of a drain without disturbing the pressure dressing.

Simple face wounds are frequently not dressed but merely covered with boric acid powder or a concentrated preparation of compound tincture of benzoin. Wounds close to the eyes may be covered with sterile petrolatum or some mild anti-

septic ophthalmic ointment, such as 1:10,000 Metaphen with or without 2 per cent Butyn. In certain instances hot wet dressings of boric acid or normal saline solution containing 20 per cent glycerin tend to relieve congestion and prevent infection.

Pressure dressings with properly shaped marine sponges or mechanic's waste are most helpful. They should be applied carefully, any uneveness or excessive pressure being avoided, and should overlap the entire perimeter of the wound margins by at least 2 or 3 cm. In dressing free grafts, Xeroform or Bettman's scarlet red gauze may be applied smoothly next to the wound. This is accurately covered with a few layers of gauze and a sterile wet marine sponge, or carefully shaped mechanic's waste dressing is applied. Over the pressure dressing a layer of gauze is placed and the entire dressing is then securely fastened with strips of adhesive plaster to prevent slipping. More gauze is applied and this dressing is covered with an encircling elastic bandage Immobilization of the part should be carried out when feasible.

A useful method of immoblizing small deep (Davis) or "postage stamp" grafts is to apply a single layer of coarse gauze snugly over the recipient area and to attach the circumference of the gauze to the surrounding normal skin with collodion. If the granulations are moist or appear to have excessive secretion, the area may be left open for twelve to twenty-four hours or longer if desired. A cardboard box or other similar barrier may be used to protect the newly grafted area from contamination. If the granulations appear entirely healthy, an immediate wet dressing may be applied to the grafted area.

Scarlet Red and Bettman's Gauze

If it is anticipated that a Bettman's gauze dressing will be used at operation, it is desirable to determine if sensitivity is present prior to operation. This may be done by applying the ointment beneath an occlusive dressing over a sensitive area, such as the inner surface of the arm, and checking the skin for any evidence of reaction after two or three days. Sensitivity may be due to the scarlet red or to the oxyquinoline sulfate or chlorobutanol which are also contained in Bettman's gauze. Scarlet red stimulates epithelial proliferation and is somewhat astringent. Weeping areas or superficial excoriations frequently heal more promptly under simple 5 per cent scarlet red ointment than when the more complicated Bettman's formula is used.

POSTOPERATIVE CARE

From two to six weeks after complete healing of many plastic and reconstructive operations, the application of cocoa butter or olive oil, followed by a gentle circular massage with the finger tips for several minutes daily, is beneficial in improving the circulation, in softening scars, and smoothing out any irregularities. Active and passive motion and, later, individually directed exercises are valuable aids in restoring function, particularly when an extremity has been operated upon and immobilization used. Scars and the thinner skin grafts do not contain sebaceous glands, and consequently their surfaces are dry. When this dryness is excessive, cracking, scaling, and other signs of irritation may be prevented by cocoa butter, olive oil, or some similar oily preparation.

CLOSURE OF DEFECTS

Many of the procedures used to close defects have become classical. The chief methods are given in the following illustrations, which are self-explanatory. The time-tested methods of Szymanowski are ingenious and usually satisfactory. Simple relaxation incisions parallel with the wound will be all that is necessary in some cases.

Methods of Closing Triangular Defects

It should be noted that the result is usually more satisfactory in the drawings depicting the closure of defects than in actual practice. Care must always be taken that sutures approximating the tips of flaps incorporate a minimal amount of tissue, otherwise the end of the flap will slough. A wide variety of closures is available (Figs 96-104).

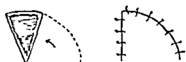


Fig. 96—Closure of a triangular defect by the method of Jasche.



Fig. 97.—Closure of a triangular defect by the method of Szymanowski.

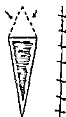


Fig. 98—Closure of a triangular defect by the method of von Ammon

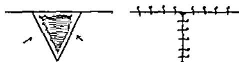


Fig. 99—Closure of a triangular defect by the second method of Szymanowski.



Fig. 100—Third method of closure of triangular defect according to Szymanowski

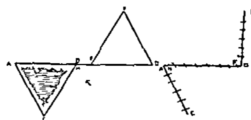


Fig. 101.—Closure of a triangular defect by the method of Burow.



Fig 102—Second method of closure of triangular defect according to Burow.

Methods of Closing Oval and Circular Defects

Defects of this type may represent decubitus ulcers, which always present problems in closure. An oval defect can be closed by any one of a number of different procedures. Lisfranc's method is simple and useful. (Figs 105-113)

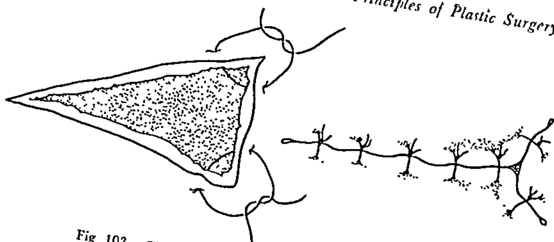


Fig 103.—Closure of triangular defect according to Davis

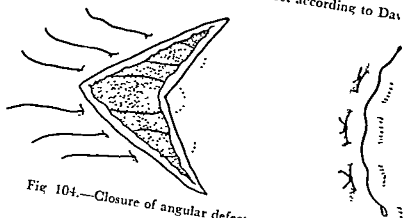


Fig 104.—Closure of angular defect according to Davis

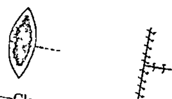


Fig 105—Closure of oval defect by method of Lisfranc

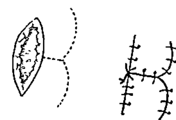


Fig 106—Closure of oval defect by method of Szymanowski.

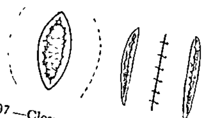


Fig 107—Closure of oval defect by method of Celsus



Fig 108—Closure of oval defect by method of Dieffenbach



Fig 109—Closure of oval defect by double flap method

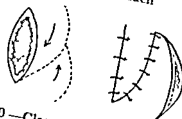


Fig 110—Closure of oval defect by method of Weber.

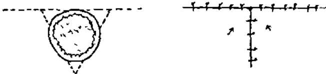


Fig. 111.—Closure of circular defect, by first method of Szymanowski.

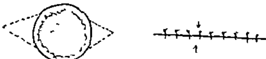


Fig 112.—Closure of circular defect by second method of Szymanowski

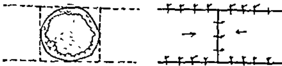


Fig. 113 —Closure of circular defect by third method of Szymanowski.

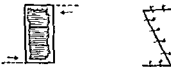


Fig. 114 —Closure of quadrilateral defect by method of Cole.

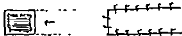


Fig 115 —Closure of quadrilateral defect by first method of Szymanowski.

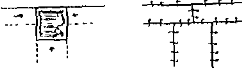


Fig 116 —Closure of quadrilateral defect by second method of Szymanowski

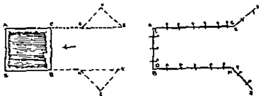


Fig 117.—Closure of quadrilateral defect by method of Burow

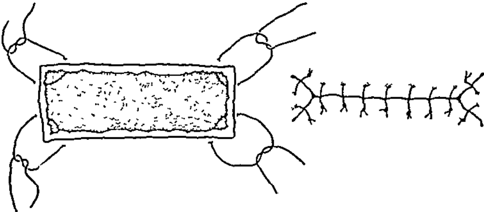


Fig 118 —Closure of rectangular defect according to Davis

Methods of Closing Quadrilateral Defects

These defects may be closed by undercutting, sliding, and several types of relaxation incisions. Special care must be taken in placing sutures in the corners of the flaps. (Figs. 114-118.)

Closure of Defects by Radical Undermining

Otto reported 11,000 battle wounds closed by excision, radical undermining of the margins, and use of marginal flaps when necessary. Extensive undermining of wound margins, if done in the proper plane, will permit approximation of wide

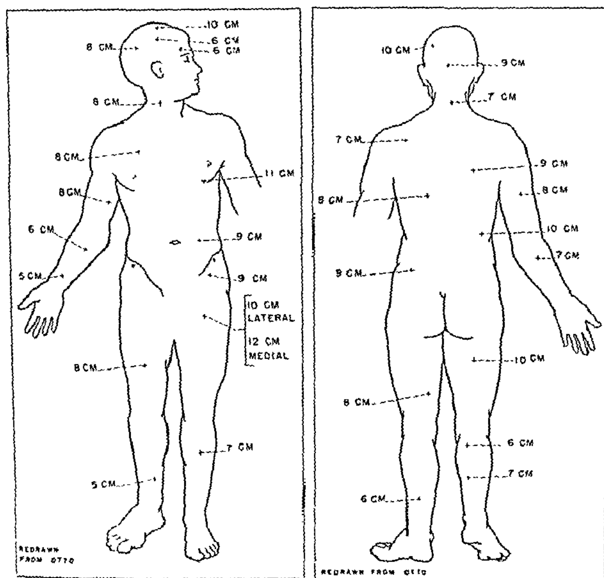


Fig 119—The degree of undermining possible in various parts of the body is indicated by the above estimates. (Otto.)

defects (Fig 119). The dissection is carried out beneath the subcutaneous fascia and fat under direct vision by divulsion with scissors. Perforating vessels must not be injured (Fig. 120). Otto used marginal flaps which were rotated across the wound in defects which were too large to permit closure with simple undermining (Fig. 121). The included angle in these flaps should not be less than 20° or greater

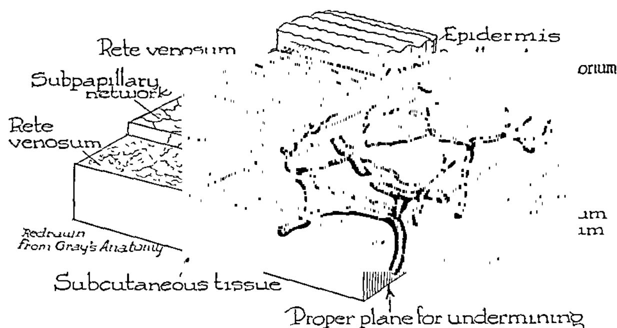


Fig 120.—The proper plane for undermining is indicated This should be beneath the subcutaneous fascia and fat with preservation of the perforating vessels.

Fig 121 —Interpolated marginal flaps with transposition (Otto)

than 45°. Tension sutures are spaced 3 to 4 cm. apart and include 2 to 4 cm. of the flap. Skin approximation sutures are spaced 1.5 cm. apart with alternating on-end mattress type sutures to prevent inversion. Compression bandages with elastic wrapping are applied to control oozing and splint the tissues.

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CHAPTER 15

THE CAUSES OF CONTRACTURES; THE TREATMENT OF SCARS; WEBBED FINGERS; KELOIDS

HARRY J. WARTHEN, JR.

CAUSES OF CICATRICIAL CONTRACTIONS

Many plastic procedures are designed to correct prominent scars which have resulted from excessive cicatricial contraction. Frequently plastic operations are marred by the subsequent appearance of excessive contractures in the scar. Therefore, it is important to consider the fundamental causes of cicatricial contraction and the methods by which this undesirable sequel of operations and injuries may be obviated.

The histologic examination of any cicatricial contracture on the surface of the body often shows an epithelial covering that is not especially abnormal. In retracted scars about the face and neck which are common after burns, the epithelial covering is practically normal, but the contraction is due to the scar tissue beneath (Fig. 122). The maximum contraction usually occurs after the surface has healed and is entirely covered with epidermis. When the histologic structure of a contracting scar is compared with a scar in which there is no contraction, it is seen that there is no essential difference (Figs. 123-126). The epidermis is apparently normal in both scars. The underlying connective tissue appears essentially the same and gives no clue to the cause of the contracted scar.

A scar consists of connective tissue, which is low in the order of tissues and is able to survive under conditions which would be fatal to a more highly differentiated tissue. The different tissues have varying capacities for surviving injuries and for repair The delicately constructed and more recently evolved cortical brain tissue repairs not at all, whereas connective tissue, one of the primal tissues, repairs readily. When conditions, either from toxic or traumatic injury or from lack of nutrition, are such that more highly differentiated tissues cannot survive, connective tissue often may live.

If a granulating surface persists for a long time, there is a tendency for an excessive amount of connective tissue to form as the result of infection and trauma to the soft granulation tissue. If this raw surface is covered with epithelium, the graft acts as a protection from further trauma and the formation of scar tissue is lessened. After scar tissue has formed, however, the epithelial covering does not prevent contraction

If a cicatricial contraction of the skin is to be corrected, a thick graft should be used. Thin grafts do not, as a rule, prevent current contraction, though they may mitigate it.

The causes of cicatricial contraction may be classified as direct or indirect. The direct cause is a toxic substance which is chemical and consists of products formed outside the cells of the body, as from bacteria, or produced within the cells as when they are affected by radiant energy. The most frequent direct causes of cicatricial contraction are from toxic products resulting from burns, chemicals, bacteria, carcinoma, trauma, and radiation. The proliferation of the endothelium with occlusion of the blood vessels following x-ray and radium burns diminishes the blood supply and results in large amounts of scar tissue replacing the more highly differentiated cells.



Fig 122—Frances K. Deformity from cicatricial contraction of the left side of neck and the left pectoral region.

Indirect causes of cicatricial contraction include the general disposition of the individual toward scar tissue formation, the portion of the body affected, lack of proper blood supply, the quantity of scar tissue, and the absence of strain or tension on the scar. Longitudinal scars over flexor surfaces tend to contract, whereas transverse scars in these locations do not. Scar tissue tends to contract where there is no strain on it and to stretch when there is tension.

Avoidance of the above direct and indirect causes, in so far as it is possible, will result in a corresponding reduction in cicatricial contractions.

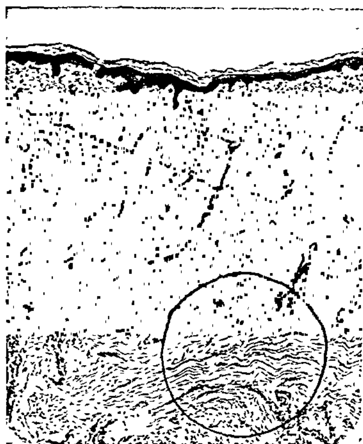


FIG 123.—F K. A section from the upper pectoral region of a contracting scar, showing the epidermis practically normal with connective tissue arranged in dense columns in the upper portion of the photomicrograph and in wavy bundles in the lower portion. (×60.)



FIG. 124 —F K The connective tissue from the lower portion of the preceding figure, showing the wavy fibers of the connective tissue with regions of leukocytic infiltration (×150)



Fig. 125.—Mrs W E. G. Noncontracting scar from the abdomen. Note the apparently normal epidermis and the wavy connective tissue. (×60.)

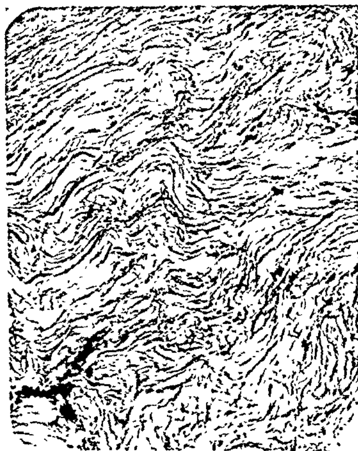


Fig. 126.—Mrs W. E G Higher power view of the connective tissue shown in the preceding photomicrograph The fibers of the connective tissue are fine, lacelike, but rather dense. (×150)

GENERAL CONSIDERATIONS IN TREATMENT OF SCARS

A large proportion of the acquired deformities that the plastic surgeon has to treat is due to scars, which may be deforming in appearance and interfering in function. In this section, various methods of treating scars and keloids will be described. A deep scar on the forehead is disfiguring, but does not interfere with function. On the other hand, ectropion of the lower eyelid or lip is both a functional and a cosmetic handicap. A scar may limit the motion of joints and tendons, retard and distort development. It may be painful, harbor infection, or be the site of recurring ulcers which often develop into malignancy. The presence of any or all of these conditions makes treatment imperative. Recent scars usually improve with time, and this change is aided by massage, exercises, and measures instituted to improve the general health. For this reason it is usually advisable to wait until the scar is from four to eight months old before operating upon it. Needless operations are thus frequently avoided and necessary operations made less extensive with better results. In hypertrophied scars, the skillful use of radium and x-ray will soften the scars and allow greater relaxation of adjacent tissues.

Smooth Scars

Scars which are smooth, soft, and stable are not greatly improved by operative measures, especially if they are extensive and inconspicuous. Excision and grafting will sometimes be very unsatisfactory. The graft may become pigmented or present a different texture from the adjacent skin, and in the donor site of the graft an additional scar is produced. The Davis method of gradual partial excision may be of value in correcting this type of scar.

Depressed Scars

Of the many methods of correcting a depressed scar, the basic principles are excision, when practical, complete relaxation of the deeper tissues, and accurate closure in layers. Davis found it advantageous, where the scar was comparatively narrow, to use the deeper portion of the scar, after the epidermis had been excised, as a buttress over which to close the skin margins.

In plastic work where the full thickness skin graft, the pedicle flap, or the sliding flap method is used, a depressed scar along the line of union adds greatly to the deformity no matter how accurately the skin incision is made and sutured. If there is a depression and a groove, the scar will spread and become very conspicuous If there is the slightest tension and the sutures are improperly inserted, though the immediate effect may appear satisfactory, as healing and contraction take place it will be seen that the scar becomes wider and more depressed. The shadows created by depressed scars of the face accentuate the disfigurement.

Esser has laid particular stress upon this occurrence and calls attention to the importance of building up the underlying fat and fascia before suturing the skin. This may be done by inserting the sutures so as to catch a small margin of the skin and a deep bite of the subcuticular tissue on each side of the wound, thus approximating the subcuticular tissue firmly. If the tension is considerable or the desirability of an exceedingly small scar great, it is best to undercut the subcutaneous fat and fascia on each side of the wound and bring the fat and fascia together by fine

silk, cotton, or catgut sutures, so forming a slight ridge just under the line where the skin is to be sutured (Fig. 127). This procedure will make the line of incision apparently bulge a little, but, as healing and contraction occur, the ridge will disappear and the scar will be on the normal level of the skin instead of being depressed and contracted. This is a highly important point when excising any scar that has been depressed and is adherent to the tissues underneath. If the depression is too great to be corrected in this manner, there should be transplanted a small amount of fat, preferably on a pedicle from the undermined skin in the region of the wound. If necessary, a free transplant of fat from the thigh can be used.



Fig. 127.—The method of Esser for preventing a sunken scar. The subcutaneous fat and fascia are so incised as to form a roll in the middle of the wound.

Unstable Scars

When extensive wounds, especially following burns, heal slowly, unstable scars usually follow. These scars are most common in regions where the loss of skin surrounds and compresses an extremity. The epithelium is very thin, the circulation is poor, the slightest trauma produces a break or blister in the epithelium, and ulceration follows. Since the circulation is poor, infection frequently develops. The instability of these scars often impairs function and sometimes actually produces invalidism. In the treatment of such scars, the infection must be cleared up, the part affected is put at rest, and the general health is improved as much as possible. A high vitamin diet should be given, and blood transfusions when indicated. Partial or complete excision of the unstable scar with the transplantation of a stable form of skin graft is the best procedure. In an extensive constricting type of unstable scar, as, for instance, on the leg, incisions may be made longitudinally down to the fascia. Davis' method is to use three incisions in the extremity equal distances apart. The length of these incisions will depend upon the size and extent of the constricting scar. This method of producing relaxation results in gaping wounds corresponding to each incision. In suitable cases grafts may be placed on these gaping wounds immediately. In many cases there is so much destruction of the underlying tissues from long-standing pressure that immediate grafting is unwise on account of the poor circulation. Under these circumstances the wounds are not grafted until they have partly filled in with healthy granulation tissue and the circulation has improved Care must be taken that more scar tissue does not have time to form during this interval. The type of graft used may vary according to the case The so-called pinch graft and the thick split skin grafts have proved satisfactory.

In constricting scars which encircle an extremity, skin grafting may be avoided and a good end result achieved by the use of one or more "Z"-plasties which break the line of constriction and increase the circumference of the part.

A scar ulcerated for years must be regarded as a potential source of malignancy and should be treated by radical excision. When true malignancy does occur, it may begin in several apparently independent areas. Microscopically, it usually shows a low grade of malignancy and metastasizes slowly. The duration of the scar

rather than the age of the patient will determine the time of appearance of the malignant degeneration. A young person with a long-standing unstable scar may develop an epithelioma at an early age.

Scar Contractures

In spite of the most careful treatment, scar contractures frequently follow severe injuries or burns Much unjust criticism is often made of the original treatment when such scars result. It is more important to save the life of the patient

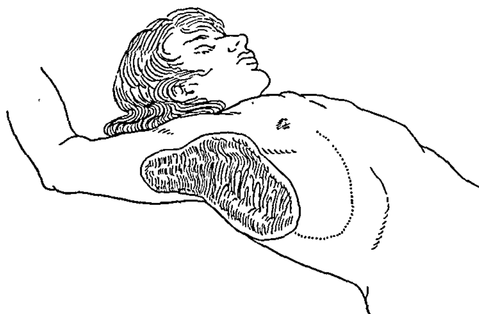


Fig. 128 —Outline of pedicle flap from anterior and lateral chest wall to cover denuded axillary apex

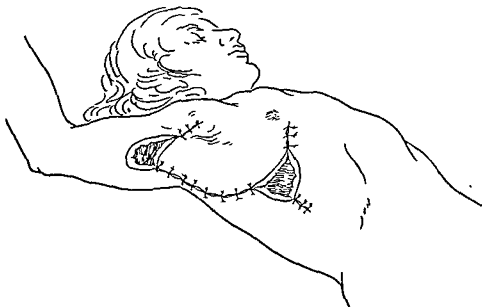


Fig 129 —Transplantation and suture of flap outlined in Fig 128

after severe trauma than to prevent contractures. The release of contracted areas is important at all ages in order to prevent deformity and impaired function. In infants and children or even in young adults who have not completed their growth, the tension and pressure of scar tissue contractures often distort the normal growth

of bone and other tissues. Shortening of the extremities as well as varying types of postural deformities can thus result. If a deformity due to contracture persists over a period of years, marked atrophy of bone and soft tissues will occur. If, however, the deformity is corrected, much atrophy can eventually be overcome. Contractures may develop in any part of the body in spite of the greatest care taken during the treatment of the original wounds. They are especially prone to occur around joints, the most common sites being in the region of the axilla, fingers, groin, knee, neck, and elbow. The prevention of contractures can best be accomplished by promoting rapid healing and early return of function. Blair and Brown recommend daily hot saline baths and the grafting of raw areas as rapidly as possible. After the raw surfaces have healed, contractures may be benefited by massage, exercise, and other physiotherapy measures.

The ideal procedure for correcting contracted scars would be the complete removal of the scar tissue, followed by closure of the normal skin margins. This procedure, however, is seldom possible, as the resulting defects are usually too large to allow closure. Under these circumstances, skin may be grafted or adjacent flaps shifted into the defects (Figs. 128 and 129). Single or multiple division of contracted scar bands, without the placing of grafts on shifting flaps, followed by overcorrection, is rarely successful, and the contractures usually recur.

Use of Z-Plasty

Davis has called particular attention to a method of relaxing scar contractures by the Z or reversed Z-type incision, stressing the use of adjacent scar infiltrated tissues (Fig 130). Many contracted scars may be corrected by this method where

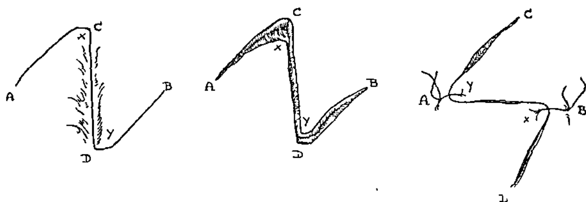


Fig 130.—Davis' Z-shaped incision for lengthening contracting band by utilizing adjacent flaps.

complete excision of the entire scar is impractical on account of its extent and location. Unless skin grafting is done or flaps shifted from a distant part, it is necessary to use scar or scar-infiltrated tissues, and often a great deal can be gained by the proper use of these tissues (Figs 131-134). To utilize flaps of scar-infiltrated tissue, some procedure must be carried out which will relax the contracting band and break the line of tension. In certain cases this may be accomplished by the Z, reversed Z, staggered Z, S or reversed S incisions, or the procedure of F. S. Mathews (Figs. 135-137). The transposition of the flaps thus formed is made possible, because there is always shortening of the tissues in the direction of the contraction and usually excess of fullness on both sides and at right angles to the contracted band Davis pointed out that the Z-type incision has been described in

many other articles and was used over ninety years ago. Recently it has been rediscovered and described as a new procedure. This method is most useful in relaxing or correcting the contractures which present a prominent bridle or web.



Fig. 131.



Fig. 132

Fig 131 —J B Extensive scar contractures of right axilla, elbow and body unsuccessfully treated elsewhere by grafts from parents.

Fig. 132 —J B, one and one-half months after correction of deformity shown in Fig. 131 by multiple Z-shaped flaps transplanted at one operation.

Technic.—Davis advocated marking the proposed incisions carefully with 5 per cent brilliant green in alcohol on the contracted area while the scar is under tension. The longest line of the Z is placed along the most prominent portion of the bridle or web. The arms of the Z are marked out on opposite sides of the central line forming angles of about 60°, with the central axis making the pattern a Z or reversed Z, depending on the condition of the adjacent tissues The arms begin at each end of the central line on opposite sides and are carried outward and downward, and outward and upward, respectively, usually ending near the level of the center of the longest line. The incisions follow the pattern and extend through the skin and scar tissue down to tissue with a good blood supply. The two flaps thus formed are undermined, mobilized, and transposed. The tip of one flap is sutured into the angle at the outer end of the lateral incision forming the second flap, and vice versa. Irregular points of the flaps are cut away and the



Fig. 133.



Fig. 134.

Fig. 133.—J. B. Posterior view of patient as shown in Fig. 131.

Fig. 134.—J. B. Posterior view of patient as shown in Fig. 132, one and one-half months after operation.

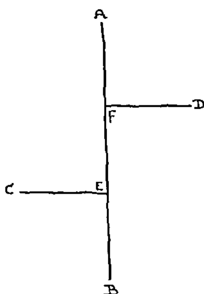


Fig. 135.—F. S. Mathews' incisions for correcting narrow contracting bands. After incisions are made and the flaps undermined, *E* is sutured to *D* and *F* to *C*.



Fig. 136.—Narrow web scar contractures of right elbow, forearm, wrist, and thumb.

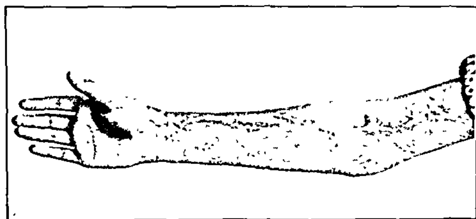


Fig. 137.—Three months after correction of deformity shown in Fig. 136 by multiple Mathews' *incisions*

wound is then closed with silk or cotton sutures. Multiple fine stab wounds may be made in the flap tips to relieve venous stasis and one or more small rubber tissue drains may be inserted beneath the flaps. Long sutures are passed through the drains and the free ends are brought out from beneath the margins of the dressings. This permits removal of the drains after forty-eight or seventy-two hours without disturbing the initial dressing. The wound is dressed with a single thickness of gauze impregnated with 3 per cent Xeroform ointment (petrolatum or Bettman's gauze) over which is placed a moist sea sponge or mechanic's waste applied under even pressure and fixed with adhesive plaster and an elastic bandage, and the part is immobilized.

In a grooved scar, the same procedure is followed. The long central incision of the Z splits the groove lengthwise and the flaps are formed just as when a bridle contraction band is present. Davis further pointed out that in many cases the flaps available are made up entirely of scar tissue and that only occasionally a bridle or web with even comparatively normal skin running up to the contracted band is found. When the scar is thin and soft, it is split its full length into two sections, which are used as part of the flaps as described previously. When the scar contraction is thick and indurated, an elongated ellipse of tissue including the heavy scar is excised and the edges are brought together with a few temporary sutures to maintain the relationship of the parts. The Z or reversed Z is then outlined, the incisions are made, and the flaps undercut and transposed in the manner already described. This latter procedure presupposes that sufficiently relaxed tissue is present to permit excision of tissue as outlined.

Many modifications of the Z incision may be used, depending upon the shape and location of the scar and the line of greatest tension of the contractures. In planning this operation, care should be taken to utilize the best available tissue.

In dealing with wide scars, relaxation may be obtained at several points or in more than one direction by using multiple Z incisions. In long contractures, as from the axilla to the hand, two or more relaxation operations may be performed at one time (Figs. 136 and 137). Deep fibrous cords should either be divided or excised and all tension should be released before the flaps are sutured. As shown in the illustrations, the tips of the flaps should be made blunt, instead of pointed, to avoid sloughing. In spite of this precaution, the tips of the flaps do slough occasionally even though sufficient relaxation has already been obtained. Fortunately the defects left by the sloughs are usually small and heal rapidly, forming a smooth scar. In all flap operations it is best to have the flaps thick and to include some subcutaneous fat, if possible, to insure a good circulation. If the flaps become cyanotic after a few hours and this condition is not readily relieved by readjusting the dressing, changing the tension, and by secondary small stab wounds, it is advisable to apply continuous warm compresses of normal saline or saturated boric acid solution. On theoretical grounds this may not appear wise, but in actual practice it is most helpful.

When the Z incisions are used on the fingers or wrist, the flaps should be short. Less constriction of the circumference will be produced by relaxing at two or more points. In extensive contractures of long standing with atrophy and shortening of the deeper tissues, as much improvement as possible should be gained at the first operation with the Z-type incisions. Six or more months later, after the deeper

tissues have stretched, the same procedure may be carried out in the same area The character of the scar usually improves to a surprising extent after the tension has been released

We agree completely with Davis on the great usefulness and flexibility of the Z-type incision method. Further indications for its use are congenital shortening of the web bed between the thumb and index finger, short contractures about the nose, ears, eyelids, etc., and poor alignment of tissues, such as an injured eyebrow, the two parts of which have healed on different levels.

CLOSURE OF DECUBITUS ULCERS

The survival of many paraplegics following World War II has necessitated the closure of numerous decubitus ulcers in these patients. The ulcers are usually situated over bony prominences, as the ischial tuberosity or greater trochanter, and it is necessary to remove the underlying bony projections before permanent healing will result.



A. *B.*

Fig 138 —*A*, Delayed pedicle flap for sacral scarring which resulted from decubitus ulcer *B*, Final result sacral scar excised, flap transferred, and intermediate thickness skin graft applied to wound from which flap came.

The surgical treatment of these ulcers usually entails the use of a pedicle flap, *unless the defect is less than 2 cm. in diameter, superficial, and of recent origin.* Before proceeding with construction of the flap the patient's general nutritional status as well as the local condition of the ulcer should be improved as much as possible. A long-standing ulcer with undermined margins will have a pseudo-bursal lining which must be excised. The wound is then packed daily to await the development of healthy granulations Furacin ointment gauze is excellent for this purpose. In the case of a sacral decubitus ulcer, the pedicle flap is outlined

with its long axis in a cephalad-caudad direction. The superior end of the flap will be situated in the loin, just below the twelfth rib. The inferior end usually overlies the gluteal muscles, lateral to the sacral lesion. Careful planning of the flap precedes the first stage operation. A safe rule is to make it no longer than two and one-half times its width. The width must be sufficient to allow excision of the ulcer, the adjacent scar, and about 1 cm. of normal surrounding tissue at the time of transfer of the flap.

Three operations are required for completion of the program at intervals of three weeks each. At the first operation incisions are made down to the deep fascia, creating the lateral margins of the flap. The intervening tissue is freed by sharp dissection in the fascial plane, thus creating a bridge attached above and below. The flap is then sutured back into place. Three weeks later an incision is carried down to the deep fascia, joining the inferior ends of the lateral incisions. This severs all vascular attachments of the flap except those which reach it from its cephalad end. These preliminary operations stimulate hypertrophy of the vessels which traverse the cephalad attachment, now termed the pedicle, and, it is believed, also accustom the flap to a lower oxygen tension and metabolic rate (Fig. 138, *A* and *B*).

Three weeks later the entire flap is dissected up, so that it is attached only by its pedicle. The circulation will usually be adequate to permit swinging its distal end to cover the defect resulting from excision of the ulcer. Before the latter is done, it is safer to wait from five to ten minutes in order to be certain of the circulation at the distal end of the flap. This can be done by noting the rapidity with which the cutaneous color returns following blanching from light digital pressure. If this is satisfactory, the ulcer with the adjacent scar is excised, any underlying prominence of bone is removed, and the distal end of the flap is swung into position and sutured into place. A split skin graft is sutured so as to cover the defect of the donor site. Graduated weight-bearing is started after four to six weeks.

For an ischial ulcer a similar flap from the upper posterior thigh is used. It is always desirable to resect the underlying ischium at the time the pedicle flap is transferred. If this bony prominence is removed, the pressure from sitting will be spread over a larger area and will not be localized to a narrow zone overlying the bone.

SYNDACTYLISM (WEBBED FINGERS)

Syndactylism is the most common congenital deformity of the hand. It involves the middle and ring finger most often, although any two or more fingers may be webbed If there is evidence that the growth of the fingers is being altered, it will become necessary to operate in infancy, but surgery is most satisfactory when carried out in childhood. Dorsal and palmar triangular flaps are outlined at the base of each finger and after overcorrection of the depth of the web these flaps provide a noncontracting floor for the new web space (Figs. 139-141). The normal web is beveled to the dorsum. The defects resulting from separation of the fingers should be covered with split grafts The obtaining of dorsal and palmar rectangular flaps from the web between the fingers should not be attempted, for sufficient tissue is rarely available and even when adequate skin is present for immediate

closure there is a strong likelihood that the web will recur and actual late deformity of the fingers may result.

In correcting webs secondary to burns the scarring will prevent the formation of triangular flaps, and tunnel grafts will be necessary. The grafting of the remainder of the fingers will depend upon the individual circumstances.

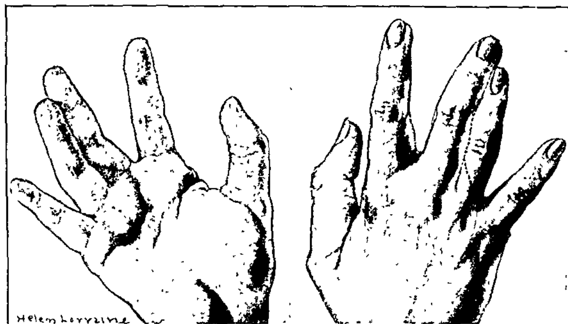


Fig. 139. Fig. 140

Fig. 139.—Incisions for operation for webbed fingers with palmar V-shaped flap outlined on middle finger.

Fig. 140.—Incisions for operation for webbed fingers with dorsal V-shaped flap outlined on ring finger.

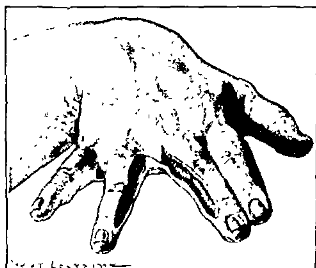


Fig. 141.—Webbed fingers separated with palmar and dorsal V-shaped flaps shown in Figs. 139 and 140 and brought across the base of the interdigital space. The raw areas should be covered with free skin grafts.

KELOIDS

An early keloid is a connective tissue overgrowth. Later on, it is composed largely of broad bundles of dense connective fibers with intervening cellular-shaped elements. Hypertrophied scars and true keloids are considered by many as separate

conditions, but others think them different stages of the same process. In a true keloid the sebaceous glands and hair are supposed to be retained, but this is not true in hypertrophied scars They may develop in certain susceptible persons, especially in young Negroes, following slight trauma or from a perfectly healthy scar (Fig. 142). They reach the greatest size where the healing has been slow and

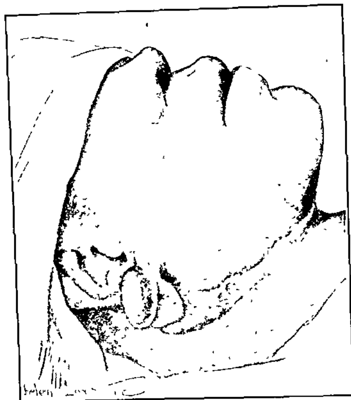


Fig 142.—Rapidly growing keloids following perforation of right ear lobe for rings. The left ear had similar keloids.



Fig. 143—Results obtained in case shown in Fig. 142 twenty-six months after treatment of right ear by preoperative and postoperative radiation and surgical excision. No recurrence. The left ear responded to the same treatment.

infection has been present, as following extensive burns. There is no known way of foretelling the development of a keloid or of preventing its appearance. Keloids give trouble not only by causing deformity in appearance, but also by interfering with function. They frequently are painful and produce persistent itching and burning. The treatment of this condition has been unsatisfactory. Simple excision

of a keloid will usually be followed promptly by a recurrence even more extensive than the original lesion. The most satisfactory method of treatment is the combination of surgical removal and skillful radiation therapy (Fig. 143). Hodges believes that thick, localized, old keloids should be removed surgically and postoperative irradiation given. This treatment should be begun immediately after operation. Radium and roentgen radiation are equally efficacious, but when large areas are involved, the roentgen ray is more practical.

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CHAPTER 16

TRANSPLANTATION OF FLAPS CONTAINING SKIN

HUNTER S. JACKSON

A free graft is a piece of tissue completely detached from its original position (donor area) and transplanted in one sitting to fill in or cover a defect in an adjacent or distant part of the body (*recipient area*).

A flap, or pedicle graft, is comprised of a portion of skin with its vascular system and attached subcutaneous fat which remains connected to its donor area by a portion of its periphery, while another portion of its periphery is transferred into the recipient area. The attachment to the donor area is termed the pedicle, through which arterial and venous circulation nourishes the flap until a satisfactory blood supply is established between the recipient area and the adjacent portion of the flap.

A free skin graft consists of a varying portion of the thickness of the skin, without subcutaneous elements. It is completely detached from the donor area and transferred wherever desired, viability being maintained for the first twenty-four to forty-eight hours by osmotic interchange with the intercellular fluids of the recipient area Skin grafts are usually divided into two general types, thin grafts and thick grafts In the thin graft group are placed the small Reverdin ("pinch") grafts, the Ollier-Thiersch grafts, and seed or implantation grafts. In the thick graft group belong the small deep grafts of Davis, the thick split grafts of Blair and Brown, the full thickness skin grafts of Wolfe-Krause, the tunnel graft of Keller, and the sieve graft of Douglas.

An autograft is one obtained from the patient himself; a homograft is one obtained from another individual of the same species. A zoograft is from a member of another species. Autografts should practically always be used, since the permanency of a homograft is exceedingly rare. It may be desirable, rarely, to use skin homografts in the critically burned patient as a lifesaving measure to prevent profound protein depletion. Such grafts may survive ten days to two weeks before sloughing, by which time the patient's general condition will permit autografting. Zoografts have no place in plastic surgery.

SOURCES OF GRAFTS

Skin grafts may be taken from almost any portion of the skin surface. The source of the graft has little effect on its success or failure, but certain considerations must be kept in mind. Generally, a thin graft will take more readily than a thick graft. This is of importance where the graft is to be used on a granulating surface or within the oral cavity. On the other hand, the cosmetic appearance of a thick graft is better, and the likelihood of contracture and wrinkling is less than

that of a thin graft. Due regard should be had for the requirements of the recipient area, as to color, texture, size, and presence or absence of hair. Where the facial defect is small, particularly about the eyelids, it is best to obtain the graft from a redundant eyelid, the postauricular region, or the supraclavicular region. When hair-bearing skin is required, it can be obtained from the mons pubis and axilla. Some care is desirable in the selection of the source of the skin graft so that the resulting scar will be as inconspicuous as possible. In obtaining large full thickness skin grafts for the face or neck, skin from the inner side of the arm or lateral portions of the chest is satisfactory The anterior and lateral surfaces of the thigh and the abdomen are the best sources for a split thickness graft.

PREPARATION OF SOURCE OF GRAFT

The surface from which the graft is to be taken may be prepared by any of the methods suggested in the discussion of skin preparation. It is inadvisable to use very strong antiseptics unless they are removed before the graft is obtained.

Since 1944, considerable attention has been directed toward the use of soaps containing G-11, or hexachlorophene. Studies on its bacteriostatic efficacy would seem to make it the agent of choice both for the surgical scrub and the preoperative skin preparation. An afterrinse should not be used, since it deactivates hexachlorophene.

If the area to be grafted is not a raw surface, the cleanup is the same as the usual donor area preparation If the area to be grafted presents any unhealed *granulations, there are several methods of preparing such a surface. Open methods,* such as frequent saline tubbings with interval wet compresses, may be the method of choice in extensive wounds of the trunk, especially of the buttocks and genitalia. Moist compresses are also the treatment of choice for granulating wounds of the face and hands. If it is advisable to administer antibiotics, they should be given parenterally, although local use has been advised by some authors. When the active infection has subsided and the granulations are bright red and healthy, only normal saline dressings should be used for at least forty-eight hours prior to operation. As mentioned, a full thickness skin graft does not take well even on a healthy granulating surface. If, because of its better cosmetic appearance or greater stability, it is desirable to use such a graft, a closed, healed wound should first be obtained by applying a split skin graft. At the time of operation for application of the split skin graft, it is best to shave off the granulations with a razor or a skin graft knife down to the yellowish base of the granulating bed Bleeding from the wound is controlled by hot saline compresses, applied under manual pressure by an assistant while the skin graft is being obtained. In certain instances of old granulating wounds with considerable subjacent avascular fibrosis, it is advisable to do a somewhat more radical dissection of the granulating area down to a more normal tissue level so that the blood supply will be adequate to support the graft.

A graft transferred to denuded bone, as on the skull, may not survive if the bare area exceeds a few millimeters in diameter If a larger area is exposed, the wound should be prepared a few weeks in advance by carefully drilling a series of *holes at close intervals through the outer table of the skull. From these holes will* appear granulations, upon which the graft may be placed. This more vascular bed will then be adequate for survival of the graft.

DRESSING OF DONOR SITE

There are many methods of dressing the donor site of the various skin grafts. In general, fine mesh gauze, either plain or impregnated with petrolatum, Xeroform, scarlet red, or Furacin ointment, should be applied, followed by additional gauze pads to effect a firm dressing. It usually is not necessary to apply a true pressure dressing or to immobilize adjacent joints. It is desirable to leave the dressing alone for ten to fourteen days, by which time the donor site for many of the grafts, such as split skin grafts, small deep grafts, and Ollier-Thiersch grafts, will be healed. Excessive soilage of the dressings during the interval may necessitate changing the outer dressing down to the fine mesh gauze. Any subsequent dressings will depend upon the appearance of the wound at that stage of healing.

FLAPS

Flaps may be divided into sliding flaps and pedicle flaps. A sliding flap (French method) is sutured into the wound from the immediate locality after making the incisions in various directions from the original defect and undermining the wound margins. The use of sliding flaps is limited chiefly to defects of a minor degree about the face. When they are used in this locality for larger areas, undue distortion of normal tissues is likely to result. The principle of the sliding skin flap is also employed in the correction of a scar with a moderate amount of depression. The scar is first excised and the skin margins are undermined; the subcutaneous fat on each side is partially freed so that it can be sutured into the center of the wound, obliterating the depression; the skin is then sutured over the filled defect.

Pedicle flaps may be divided into three general types: simple, compound, and lined flaps. The simple pedicle flap is composed of full thickness skin and a varying amount of subcutaneous tissue. The compound pedicle is made up of full thickness subcutaneous tissue with the addition of bone, cartilage, or muscle. In a compound flap containing bone, the periosteum is included with the bone, without separating it from its normal position. An example of such a compound flap is one taken from the clavicle to fill a defect of the jaw (Figs. 144-146). When muscle is transplanted, as in the closure of a large thoracic wound, the muscle is left attached to the skin and subcutaneous tissue with its normal blood supply. Cartilage, forming a part of a compound flap, is easily implanted into the flap as a free graft, since the cartilage is usually taken from the costal region. When the defect, which has been lined with mucous membrane or skin, is to be repaired by a pedicle flap, it is necessary to line the flap with epithelium before it is transplanted. Unless this is done, the flap will contract or be lost entirely. The flap may be lined by several different methods: the raised flap may be folded, or two flaps may be raised and their raw surface allowed to grow together, and then the flaps may be transplanted. The simplest way to line a flap is to place accurately a split skin graft or full thickness graft under that portion of the flap which is to be lined, adjusting the raw surface of the graft to the underportion of the flap. The pedicle flap is then sutured back into its bed and even pressure is applied with foam rubber or sea sponge. After ten days to three weeks, the flap is raised and transplanted to its new position. Careful selection must be given the type and texture of skin which is to line the flap. Hair-bearing skin should not be used where the lining is to replace mucous membrane, such as within the mouth. A pedicle flap to restore an eyelid should be

lined with mucous membrane, as even the thinner split grafts may contain hair and cause too much irritation for a satisfactory result.

Pedicle flaps are further classified as open or tubed, depending on whether the undersurface of the pedicle is an open, raw, granulating surface or whether its lateral margins have been sutured together in the form of a tube. Each has its indications and advantages. The transplantation of a pedicle flap may be immediate, being dissected up and transplanted at one operation, or it may be delayed in order to assure proper circulation. In the delayed transplantation, varying inter-

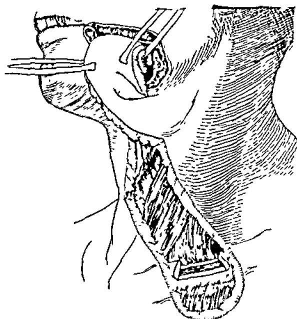


Fig 144.—Reconstruction of defect in the lower jaw by a pedicle flap including a portion of the clavicle. The flap is long enough to reach over the section of clavicle into the mouth and completely envelops the bone.

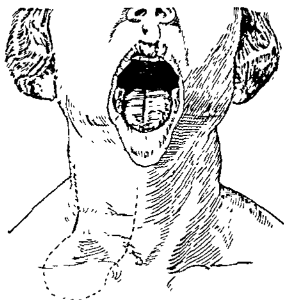


Fig 145

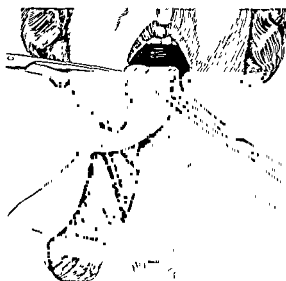


Fig 146.

Fig 145.—Lines of incision for repair of defect in the midline of lower jaw. A piece of rib has been previously grafted under the skin of the flap

Fig 146.—The flap with its grafted bone is turned into the defect of the lower jaw The skin is long enough to fold over the grafted bone.



A.



B



C.

Fig. 147.—*A*, Abdominal tubed pedicle flap to cover old burn defect on inner surface of left ankle. *B*, Flap migrated to defect via intermediary wrist attachment. *C*, Flap severed; final smoothing out not yet done.

vals of time are allowed between the dissecting of the flap and its removal to its new bed. This delayed transfer may require multiple stages in order to develop the circulation. Flaps may be transplanted by successive migration stages from distant parts of the body. (Fig. 147.)

SOURCES AND GENERAL PRINCIPLES

The chest and abdomen afford the largest areas of skin on the body from which to obtain pedicle flaps. These flaps are usually tubed and can be used to fill large defects of the face, neck, axilla, and upper extremities. Other principal sources of pedicle flaps are: the anterior and lateral surfaces of the arm, a good

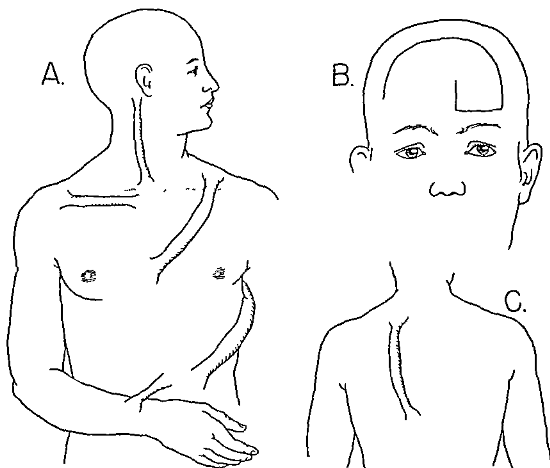


Fig 148.—*A*, Anterior donor areas most often used for tubed pedicle flaps. *B*, Open forehead flap *C*, Posterior donor area for tubed pedicle flap

source for a tube flap for large defects of the face, the back, for tube flaps for large defects of the face, neck, and axilla, the neck, for small defects of the cheek, lip, and external ear (Fig. 148). The disadvantage in this cervical source is the formation of additional scars in a conspicuous area. This is particularly true in a female patient. The scalp is the best source for hair-bearing skin transplants and may even be used for a double pedicle flap for defects of the chin and lips in the male The forehead is an excellent source for rhinoplasty and for covering small or medium-sized defects of the upper half of the face The skin of the lower back may be used for defects of the hand and forearm, while the lower thigh and calf may furnish flaps for repairing defects of the lower extremities and are particularly suitable for covering the sole of the foot (so-called crossed leg flaps) (Fig 149)

Often incisions may be made or flaps may be so shaped as to secure tissue from the neighborhood, which at first might seem impossible. Due regard must always be had for nutrition of flaps, and the pedicle should be located preferably in the general direction of the blood supply of the skin from which the pedicle is formed. The flaps should be handled as little and as gently as possible. It must be borne in mind that unnecessary trauma not only destroys living tissue in a flap, but adds an extra burden to the blood supply which must absorb the injured cells and bring nutrition for the repair of the defect. To this end, sharp skin hooks, mosquito hemostats, and small thumb forceps do much to minimize tissue damage. In very vascular regions, such as the face and scalp, it is often possible to disregard the direction of the blood supply in making a flap because it is so abundant and the collateral circulation is so great that a flap may be sufficiently nourished if the pedicle is large enough, even though the blood must come from the opposite direction of the normal supply.

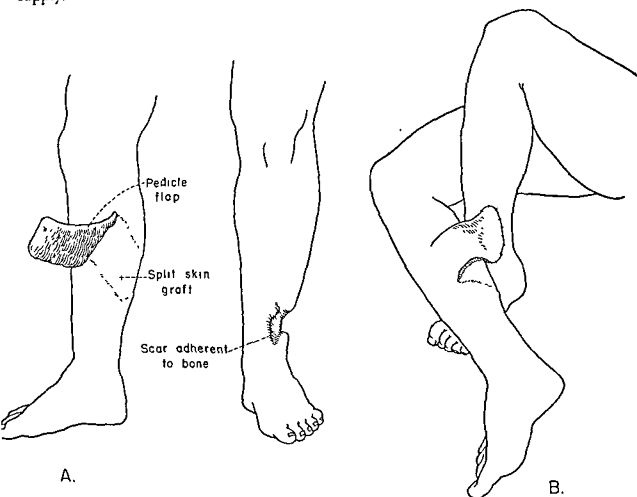


Fig 149.—*A*, Flap elevated on donor leg, showing skin graft applied to cover flap bed. Defect in opposite leg. *B*, Flap in place after excision of scar.

Besides handling the flap gently and providing sufficient nutrition through its pedicle, care must be taken to insert the sutures so as to avoid too much tension. No matter how carefully the pedicle may be handled or shaped, if it is sutured so that there is too great tension or torsion, the blood supply will be obstructed and the flap will be partially or totally destroyed. Occasionally when tension in a flap is unavoidable, it is best to concentrate it upon one or two tension sutures that will

produce pressure only in one or two areas and relax the rest of the flap so there will be enough nutrition along the margins for satisfactory union. The nutrition of a flap may be imperiled also by venous stasis. McIndoe and C. H. Mayo emphasized this point. Not infrequently the blood supply to a flap would be sufficient except that the venous return is imperfect and blocks the capillaries, which in turn prevent the feeble arterial current from being effective. Wherever a large flap with a narrow pedicle is transplanted, this condition may result and should be carefully *avoided by making several short stab wounds in the substance of the flap and* by leaving small gaps between the stitches along its margins through which the venous blood may escape, thus relieving the passive hyperemia.

If the flap cannot be carried to the affected part, as is done in defects about the face, the affected part can sometimes be carried to the flap, as in plastic operations on the hands or on the lower extremities. Defects about the hand, forearm, or the elbow may be repaired by a flap from the abdomen, which is dissected up as a bridge of tissue between two parallel incisions and is left attached at each end. The defect on the hand is prepared for a graft and the hand is inserted under the bridge, and the edges of the skin of the bridge of tissue are sutured to the margins of the wound of the hand. After about two weeks the flap is gradually cut away. By making a flap with its broad base from the upper part of the abdomen, the whole portion of the flap except its base can be sutured to the defect. In this way lesions of the palm of the hand are satisfactorily repaired and the patient is much more comfortable than when the hand is carried to the back. By this latter method virtually a closed wound is obtained, without the attendant increase in fibrosis that an open granulating flap would entail Shaw and Payne utilized a one-stage tubed flap, pedicled on the inferior epigastric artery, for small defects about the fingers and hand, elevated, tubed, and attached to the recipient area in one sitting.

It is always necessary to see that the flap is sufficiently nourished by its new location before the pedicle is divided When the pedicle is first severed the flap always becomes pale but if the patient is young and relatively healthy and the flap is in good condition, a pedicle can usually be cut safely at the end of two to three weeks. If in doubt, it is advisable to compress the pedicle with a soft-bladed clamp or an elastic band for an hour or more daily for several days before severing it. In this way collateral circulation is developed. At times it is desirable to sever one-half of the pedicle and, after seven to ten days, to divide the remaining tissue.

Hynes' atropine absorption test is a simple and apparently accurate means of estimating the blood supply in flaps and tubed pedicles. It is primarily a qualitative test, which is dependent on the absorption of atropine in sufficient quantity within thirty to forty-five minutes to produce two of three easily detected symptoms and signs· About twelve to fourteen days after transfer of the flap or pedicle into the recipient area, a soft-bladed clamp is applied in such a manner as to compress the circulation of the long axis of the flap. Atropine sulfate, 1/75 grain, is injected subcutaneously into the recipient end of the flap or pedicle. Blurring of vision, dryness of the mouth, and increased pulse rate, with the time of their appearance, are noted. The presence of two of these within thirty to forty-five minutes indicates adequacy of circulation between the transferred end of the flap and the recipient area, and the pedicle may then be severed.

If it is desired to transfer a long narrow flap from the neck to a region on the face, it is too hazardous to imperil the nutrition by doing the operation in one stage.

The circulation of the flap, however, can be developed by first outlining the flap by incisions, then the bridge of tissue for the pedicle is undermined, and the incisions are sutured. In this manner the nutrition at the ends of the flap will be increased. After ten to fourteen days the end that is to be severed is divided in sections at intervals of three to five days so that all of the nutrition will be gradually developed from the pedicle.

Blair, in 1921, published certain conclusions which are still essential in making and transplanting successfully skin flaps for the correction of defects. In the region of the neck and face of a man, rather long flaps can be made with little danger to their vitality, provided the return circulation is not retarded by gravity and not obstructed by kinking or torsion of the pedicle. In women and children, the circulation of the face and neck is not so vigorous, and equally long flaps are less likely to survive. If a flap sloughs in its original position, the portion lost will be considerably less than if it had been transplanted immediately. The slough of an untransplanted flap is likely to be superficial without necrosis of the full thickness of the skin, yet a slough occurring after transplantation is more apt to involve the entire thickness of the flap. If a recently transplanted flap shows evidence of sloughing, it is safer to replace it in its original wound By so doing, time will be saved and usually a smaller part of the flap will be lost. If a flap is to be split into two or more narrow flaps to cover defects, such as those of the eyelids and lips, the splitting should be delayed until the time of transplantation. If any part of a flap sloughs in its original bed, that area, regardless of how superficial the slough may be, should not be transplanted.

There are other fundamental principles about the technic of cutting and transplanting flaps. In order to allow for shrinkage the usual flap should be made somewhat larger (usually one-third) than the defect it is to fill. It should correspond fairly accurately in shape, though flaps made from normal tissue are pliable and can easily be adjusted to fit a wound of almost any shape. Long, pointed, and sharp-cornered flaps should be avoided, as the circulation in the tips is often inadequate, and a slough will result. The subcutaneous fat should be slightly thicker than the immediate need in order to allow for shrinkage. When the flaps are obtained from the forehead, where there is little if any subcutaneous fat, the size and shape of the flap must be cut very accurately. Accuracy is especially important in rhinoplastic operations. A pedicle flap should be as broad as possible, but where the tissue must be twisted, the pedicle should be narrower than the main body of the flap. The length of a pedicle flap for immediate transplantation should not be more than two and one-half to three times its width unless the pedicle contains a main artery and vein A main artery is not essential if the pedicle is sufficiently wide, and it is usually better to have the flap thick enough to contain a number of small vessels for its nourishment. The length of a single pedicle flap with delayed transfer should not be over three to three and one-half times its width.

TUBED PEDICLE FLAPS

One of the most interesting and valuable procedures in plastic surgery is the development of the blood supply from a comparatively small pedicle. In extensive reconstruction work about the face this procedure is essential for success. "Tubing" of the pedicle, of such a size and shape as may be best suited to the facial defect,

was first described and demonstrated in 1916 by Filatow of Odessa. Gillies of London made an independent but similar report in 1917 and subsequently popularized this method. The tubed pedicle is prepared by making two parallel incisions through the skin and subcutaneous tissues in the selected donor site (Fig. 148). After dissecting the pedicle from its base to the margins of the proposed flap, the edges of the skin of the pedicle are brought together with a few interrupted and continuous sutures of silk or cotton. In this way the raw surface of the pedicle is protected from infection and also from the trauma and loss of blood to which an exposed granulating surface is subjected. The margins of the wound from which the pedicle has been dissected are undermined and united beneath the tubed pedicle so there is a minimum of raw surface exposed (Fig. 150). If necessary, because of undue tension, the wound may be surfaced with a split thickness skin graft. Ten to fourteen days later one-third of the flap is dissected from its bed.

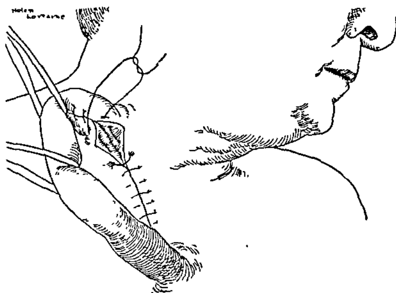


Fig 150.—Gillies' four-point suture for apposing raw triangular ends in formation of a tubed pedicle flap.

If the flap is to cover part of the cavity of the mouth, its raw surface is grafted with thick split skin grafts, or two flaps may be developed with tubed pedicles and one turned with the epithelial surface within the mouth and the other with the skin external. At intervals of about one week the flap is again dissected in three stages, covering a period of three to six weeks, until it is entirely free except for the pedicle. This procedure will develop a blood supply through the pedicle so that the flap may be transferred without fear of insufficient nutrition. Sometimes, as recommended by Gillies, a large flap to cover an extensive defect of the face can be raised from the front and upper part of the chest by having two tubed pedicles, one on each side of the neck. When the pedicle is severed after the flap is in place, it may be cut gradually, severing about one-third at a time, at intervals of one week, or it may be compressed with a soft-bladed clamp or a rubber band for an hour or more daily for several days before it is severed. In this way the blood supply is gradually thrown upon the new attachments of the flap in such a manner that the local nutrition is surely established, whereas a complete severing of the pedicle without preliminary preparation might result in such poor nutrition that the flap would slough.

When the pedicle or the lateral skin attachments of a tubed flap are divided, local anesthesia may be used. It should not be injected into the flap, however, but into the tissues adjacent to it. Injection of the anesthesia into the flap itself may interfere seriously with the circulation. Where gradual division and undercutting are done, it is necessary to dissect off the thin layer of scar tissue and remove all granulating tissue before shifting the flap into the defect. When the tubed portion is to be used or when the unused portion of the tube is to be replaced in its original bed, the superficial scar where the skin margins were brought together, along with the deeper scar leading to the central portion of the tube, should be excised before the tube is opened. If the tube portion of the flap is used in the reconstruction, allowance must be made for the shrinkage of the tissue constituting the tube. When a wide section of skin is required, the double pedicle flap sutured back into its bed without tubing the pedicles should be chosen, because of less shrinkage.



Fig 151 —Tubed pedicle flap extending from abdomen to lumbar area with an intervening "bridge" attachment

The unrolling or opening of the tube is an important step. All incisions in the subcutaneous fat of the tube must be made longitudinally and as few incisions should be used as necessary to allow satisfactory opening of the tube in order to avoid damage to the blood vessels of the flap. After the unrolled tube is sutured into its new position, the pedicle end of the tube must be carefully placed so that there is no kinking either from gravity or from its new position. Three to four weeks or longer must elapse to permit healing of the flap in its new bed. The pedicle is then transferred to its new position, removed, or sutured back into its original bed, as may be indicated.

Very long tubed flaps may be made with success by the delayed transfer method. A procedure reported by Webster makes even longer tubed flaps possible. His method (thoraco-epigastric flaps) is to raise and tube the flap in two or more sections, with an interval of untouched skin between each tube (Fig. 151). This assures the blood supply during the early stages when it is usually unstable. After a brief period of time, these untouched areas of skin are successively dissected, the tube is completed, and later the tubed flap is transferred. At the original operation it is advisable to mark by short stab wounds in the skin the exact location of the incisions which are to complete the tube later on. The small scars made by these stab wounds will act later as a guide for the incisions. At the time of the second operation it is important to carry the dissection well down to the fascia.

MIGRATING PEDICLE FLAPS

Tubed flaps may be migrated by "waltzing," by "caterpillaring," or by using an intermediary such as the arm or leg. When a flap cannot be placed directly upon the recipient wound, *a tubed pedicle flap should be used. "Caterpillaring" or*

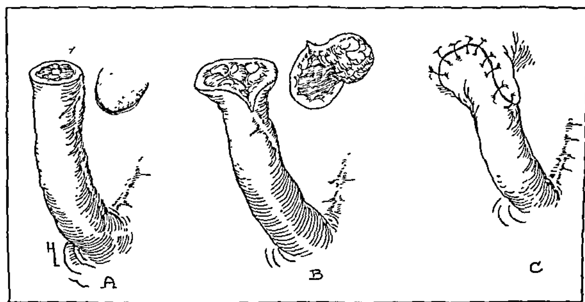


Fig 152 —*A,* Trap-door flap Stippled area is the imprint of end of tubed pedicle on the wrist, which is incised and undermined. *B,* Trap-door flap reflected and prepared end of tubed pedicle. *C,* Tubed pedicle and trap-door wrist flap sutured. When migration is completed, the trap-door flap is returned to its original bed.

advancing a tubed flap in the direction of its axis is sometimes useful when it is desirable to transplant a flap from an adjacent area and when torsion on the tube must be avoided A flap may be turned, for instance, to the margins of the wound and kept there until the nutrition is well established. Then its pedicle is cut and turned over the defect A flap from the abdomen may be sutured into a trap-door wound made on the wrist for its reception and migrated via this intermediary (Figs. 147 and 152). After it has taken, the pedicle to the abdomen is cut and the wrist with the transplanted flap is carried to the face or other area. The flap is sutured into its new position, the pedicle to the wrist is severed at the proper time, *and the trap-door flap on the wrist is restored to its original condition.*

CROSSED LEG FLAPS

The crossed leg flap is an open flap used in repair of surface defects of the lower extremities, in which the opposite leg serves as the donor area for the defective leg. The general principles of such a flap differ little from flaps on other areas of the body. Careful planning as to size, direction of blood flow, proper position to avoid tension or torsion, and immobilization during the time of transfer are imperative for success.

Indications for the use of a crossed leg flap are unstable or painful cicatrices attached to bone, scarring or surgical defects over the weight-bearing portions of the foot, and extensive scarring over the Achilles tendon.

Usually two preliminary steps two to three weeks apart are necessary to insure adequate circulation prior to transfer of the flap into the defect. When the flap is initally constructed at the first operation, a split skin graft is applied beneath it to cover the bed from which it came. The transfer may usually be done two weeks after the second delaying operation. The day before transfer, it is wise to apply plaster casts to both legs which will produce the desired positions, permitting transfer of the flap and at the same time immobilization of the extremities. This will enable the surgeon to evaluate the comfort of the casts, the status of the peripheral circulation, and will also permit setting of the plaster. This will avoid the possible production of tension on the flap due to mishap during the setting of casts applied immediately after transfer of the flap. If the casts are deemed unsatisfactory, they may be replaced, waiting another twenty-four hours before operation to recheck these factors Adequate windows are cut out of the casts over the flap and the recipient area. At the completion of surgery cross-bracing is applied to join solidly the two casts without tension or torsion on the pedicle.

Usually three weeks must elapse before the pedicle may be cut half across. In this manner, as mentioned earlier, sufficient collateral circulation from the recipient area is developed before severance, which may be carried out a week later. The casts are removed, and the severed edges of the pedicle are appropriately trimmed and sutured in place on their respective legs. In the case of a flap applied to the sole of the foot, weight-bearing is carefully begun four to six weeks after the last procedure During this interval, physiotherapy is indicated to mobilize the joints of both legs which will have stiffened while in the casts

Contraindications to the use of a crossed leg flap are: undesirable scarring on the donor leg in a female patient, advanced age of the patient which might result in permanent joint damage due to the immobilization, and preexisting arthropathies.

DOUBLE PEDICLE FLAPS

A double pedicle flap is made by raising a flap attached by a pedicle at each end and sliding it to the defect. Such a flap from the submental and upper cervical regions is useful in restoring the lower lip and chin. A flap can also be made from the scalp with its attachments in the temple on each side and brought down to restore the lower lip and chin in the male. This method is particularly suitable for large defects in the region of the midline of the face. A similar flap, termed a "visor" flap, has been used by Straith and Beers in traumatic avulsions of the anterior scalp to restore the forehead hairline, using a double pedicle flap which brings forward hair-bearing occipital skin.

On occasion a double pedicle sliding flap may be useful on an extremity where there is a long narrow scar attached to bone. After the flap is slid over to close the defect, the counter defect is covered with a split skin graft.

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CHAPTER 17

FREE GRAFTS OF SKIN AND MUCOUS MEMBRANE

LEROY SMITH

The transplantation of skin and mucous membrane has been in practice for centuries. However, it was not until Reverdin in 1872 published his work under the title of *Epidermic Grafts* that interest was aroused in this procedure. Other surgeons, namely, Oliver, Thiersch, Krause, and Wolfe followed in rapid succession with reports of their experiences with various types of skin transplants. The indications for the transplantation of skin are numerous, but mainly where skin has been destroyed or damaged following trauma and disease. The transplantation is not a success unless the skin lives and serves functionally and cosmetically the purpose for which it was applied. Improvements in recent years have contributed notably to our understanding of the best methods to be used to attain this end. Most skin that is transplanted is autograft, that is, the patient's own skin is used for transplantation. Experimentally, homografts—skin taken from one individual and placed upon another of the same species—have been tried, but so far successful "takes" have not been permanent.

There are multiple classifications of the free grafts (Fig. 153) of skin and mucous membrane, but one of the simplest is as follows:

1. Split thickness grafts
   a. Epidermal grafts
   b Small split grafts
   c Intermediate grafts
   d. Dermal grafts
2. Full thickness grafts
   a. Large full thickness grafts
   b. Small full thickness grafts
   c. Sieve grafts
3 Tunnel grafts
   a Split thickness
   b. Full thickness
4. Composite grafts

PHYSIOLOGIC PROPERTIES OF GRAFTS

When one transfers a free piece of skin and applies it to a raw surface and maintains this contact by immobilization, immediate healing begins. The recipient site begins to throw out an exudate which contains fibrin. This fibrin forms a network which attaches itself to the undersurface of the graft. Into this fibrin network go leukocytes and fibroblasts followed by a relatively rapid formation of small capillary buds which at the end of three days can be seen extending into the lower layers of the graft. By the end of the seventh day, there is a fairly firm union between the two surfaces. For the first twenty-four hours the skin receives its nourishment through the plasma in the exudate. After the third day, the nourishment

is almost wholly taken over by a circulation of blood through the capillary bed. From the time the graft is applied to the end of the first week, the development of infection, hemorrhage, or motility will disturb the normal healing process and a successful "take" will be jeopardized. It is within this period that all grafts should receive the utmost care and protection. If one suspects that either of the above complications has arisen prior to the seventh day, measures should be taken to correct

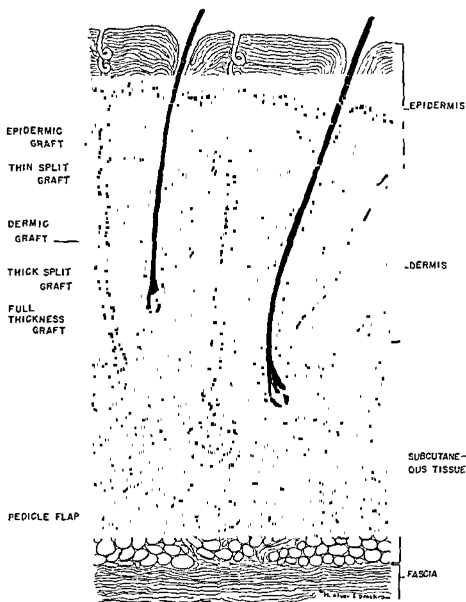


Fig. 153.—Section of skin showing the different cellular layers Approximate layers included in the various grafts are described on the left side of the figure.

it. Otherwise, the graft should not be dressed or disturbed. The symptoms suggesting danger are: (1) elevation of temperature, (2) excessive swelling, (3) discoloration around the graft site, (4) pain, and (5) shifting of the bandages overlying the graft. If early attention is paid to these signs and symptoms, and measures are taken to correct them, one may avert total failure. The size, thickness, and location of the grafted skin have a definite influence on its physiologic pattern of behavior. It is known that full thickness or thick split thickness grafts will not take

where there is evidence of infection on the recipient area, where careful hemostasis of the grafted area has not been complete, and where the slightest shifting of the graft has taken place. Even as late as the fifth day these complications may end in failure of the graft to grow.

Thick grafts frequently change color when transferred to a new environment, becoming highly pigmented, particularly when placed on exposed surfaces. However, they do have distinct advantages in that contraction is very slight following healing and the resistance to trauma is excellent and they retain their elasticity, approaching that of normal skin. If these grafts contain hair follicles, one may expect a continuation of growth of hair following transplantation. The resistance to local infection following healing is the same as that of the surrounding skin. In thin split thickness and epidermal grafts one may expect successful "takes" on sites that are covered with granulation tissue. These grafts do not require the high degree of immobilization that we find with the thicker skin transplants For this reason they can be used as epithelial dressings where infection is present and where one cannot obtain fixation for a long period of time. Their main disadvantages are that contraction, which frequently may be as much as 50 per cent of the total area, may develop and their resistance to trauma is extremely low. The elasticity of thin grafts is less than that of normal skin and, consequently, their application over joint surfaces should be avoided.

SPLIT THICKNESS GRAFTS

Split thickness grafts may be divided into four classifications, namely, epidermal grafts, small split grafts, intermediate grafts, and dermal grafts.

The epidermal graft, or the so-called "isle of Thiersch," is taken from the outer layer of the skin including the epidermal layer and the tips of the papillae. It is preferable to select as a donor site that portion of the skin surface which has no or a relatively small amount of hair, such as the flank or the inner surface of the arm and thigh. Its application can be made on fresh or raw wounds or on healthy granulating wounds. Occasionally, it may be used on infected granulating tissue as an epidermal covering. This choice is made, however, only in the case of an emergency.

Technic for Removing Split Thickness Grafts

The donor site is first prepared by scrubbing the skin surface with soap and water the night before and covering it was a sterile towel, which is left in place until the graft is ready to be taken. The towel is then removed and the area is painted with 70 per cent alcohol which is allowed to dry. The method of obtaining epidermal grafts is the same as that applied to any type of split thickness of skin. One may use a freehand razor-sharp knife, having the assistant maintain traction on the skin by holding two boards, one at each end of the area to be removed, flattening this area and putting it under moderate tension. The knife is then used to shave off the outermost layers of the skin in the desired width and length (Figs. 154 and 155). To facilitate this, the Blair suction box may be used (Fig. 156) with which the operator can maintain a more even amount of traction.

The most satisfactory method is to remove these grafts by the use of a dermatome, such as the one devised by Padgett. This dermatome consists of a drum over

which a blade revolves. The blade can be set at various distances from the drum, giving a uniform thickness to the graft. The technic is as follows: The drum is cleansed first with alcohol and then with ether to assure absolute freedom from moisture.



Fig. 154.—Two boards used to keep the skin tense while taking a graft.

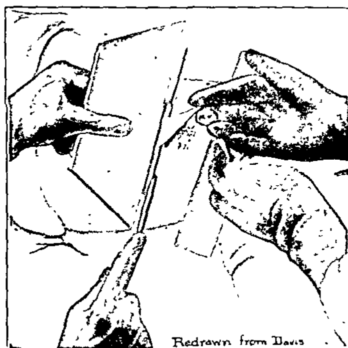


Fig 155 —Graft is cut with a long amputating knife while the wooden boards keep the skin tense

The drum is covered with an adhesive which is made for this purpose. Following cleansing of the donor site, the glue is distributed over the area corresponding to that of the drum (10 to 20 cm) The surfaces of the drum and skin are allowed to dry thoroughly and the knife is adjusted to the desired thickness by the gauge

on each side of the drum. The drum is placed on the surface with the two adhesives in contact and rotated slowly upward, pushing the knife backward and forward across the elevated portion of skin This allows the skin to remain adherent to the surface of the drum until complete removal of the graft. The skin is then removed from the drum and all of the adhesive is removed from the skin before it is placed upon the recipient site (Figs. 157 and 158). There is also an electric dermatome which cuts the skin by using a vibrating blade guarded by a crossbar which can be lowered or raised to any desired thickness. The advantage of such an instrument is obvious in that long sheets of skin can be obtained and no adhesives are necessary. The use of the dermatome also has a distinct advantage in that the operator is able to obtain skin from any curved surface, such as the chest wall, which normally would be very difficult to obtain with a free blade.

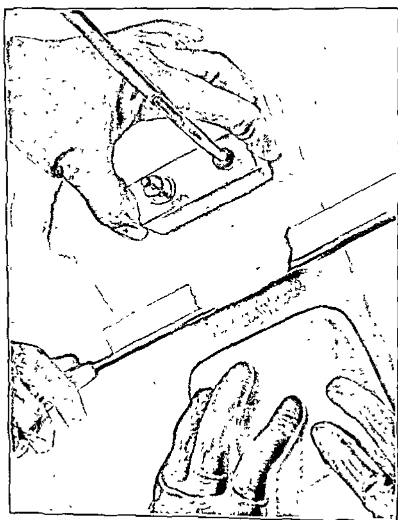


Fig. 156—Cutting thick split graft from thigh according to Blair, using suction *retractor.*

Following the removal of the skin, the donor site is dressed with one layer of scarlet red gauze over which is placed a plain gauze dressing This is usually left in place for two weeks, after which time all dressings can be removed. The wound is at this time usually covered by epithelium

Epidermal grafts should normally be 0.0010 to 0 014 inch in thickness. These grafts may be laid on the recipient site covered with one layer of scarlet red or fine mesh gauze. They can be immobilized by using external gauze bandages. How-

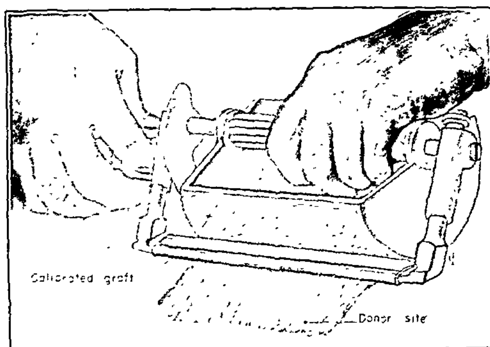


Fig. 157.—The skin adheres to the dermatome by glue adhesive. The drum is revolved upward as the blade is moved transversely. The desired thickness is obtained by predetermined distance of blade from the drum.

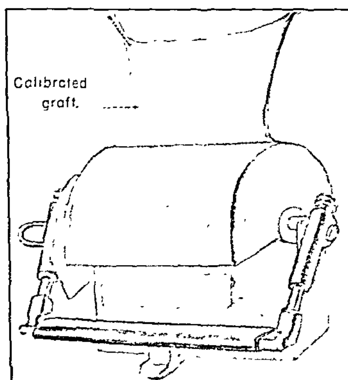


Fig 158.—Skin is removed from the drum by elevating it with forceps and wiping the glue from its surface with dry gauze.

ever, in most instances, it is best to suture the edge of the graft to the surrounding edge of the skin with fine four 0 or five 0 silk. While this is not always necessary, it is a measure of safety that will give an added insurance against loss of the graft by movement of the transplant.

The aftercare of epidermal grafts is quite simple. The fixation bandages are left in place until the fifth to the seventh day. If there is any evidence of complication, as has been described above, the dressing should be removed prior to this time. At the end of the seventh day all bandages may be removed and the graft gently sponged with 50 per cent hydrogen peroxide to remove any excessive amount of exudate which may have accumulated along the edge of the graft. Inspection should also be made for any evidence of sloughing. If any area of the graft has sloughed, this should be dissected away with scissors, care being taken not to injure the surrounding healthy graft. If this is not done at this time, the products of decomposition of the slough will almost certainly injure the surrounding normal tissue. Subsequent dressings should be of fine mesh or scarlet red gauze next to the grafted surface with a moderate amount of pressure to prevent excessive trauma. All sutures are removed, usually between the seventh and tenth days, depending entirely upon whether the danger of shifting of the graft is present. Dressings are then changed every forty-eight hours until the third week, following which the graft should be sufficiently healed to require no further protection. As has been stated before, it is to be expected that the grafts will undergo some contraction, depending upon whether the underlying bed is loose or rigid. If it is loose, such as muscle or fat, frequently these grafts will undergo as much as 50 to 75 per cent shrinkage. If the graft is placed over a rigid surface, contraction will not be as great. These grafts will not withstand trauma, such as would be received on the hands and feet, and if they are applied to those regions subsequent ulceration may be expected. The epidermal grafts are excellent for lining cavities and for substitution of the mucous membrane in the oral cavity.

Small Split Thickness Grafts

Small split thickness grafts, or the so-called Reverdin grafts, consist of small areas of epidermal skin, and are sometimes known as pinch grafts. There is very little difference in the characteristics or indications between these and the small full thickness grafts, except that there is a higher percentage of "takes" and occasionally they may be used as buried or seed grafts where the excessively thick granulations are present. These grafts will grow on raw or granulating surfaces. Just like large epidermal grafts they will take better upon granulating surfaces that are thin and noninfected. They are used mostly to cover surfaces which are moderately infected and as emergency grafts in larger denuded areas where quick epithelization is desired. They have the distinct disadvantage in that they react poorly to trauma and the areas between the grafts are covered with fibrous tissue. An advantage is that large areas can be covered with skin received from a relatively small donor site. Frequently, following application of these grafts in infected areas, hot wet saline dressings may be started immediately and changed at the end of forty-eight hours. At this time grafts which have not become definitely adherent should be removed. These wounds are dressed at the end of every forty-eight hours until complete epithelization has occurred. Small split grafts are obtained by piercing the outer layer of skin with a straight sewing needle and elevating the point so as to produce a tenting of the adjacent skin. With a sharp knife, the apex of the

pyramid is removed (Figs. 159 and 160). The donor sites, following removal of the grafts, are covered with hot saline packs until bleeding is controlled and then covered with scarlet red or fine mesh gauze over which plain cotton gauze is applied.

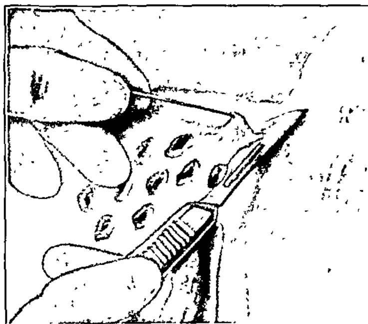


Fig 159.—Method of cutting small grafts.

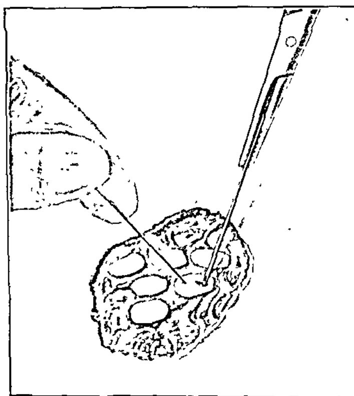


Fig 160.—Method of placing small grafts

Intermediate Grafts

Intermediate grafts are thick split grafts and are the most widely used skin grafts today. This is because their physiologic characteristics are such that they

will give the desired covering and, at the same time, the donor site will heal spontaneously. These grafts should range from 0.014 to 0.024 inch in the male and from 0.010 to 0.016 inch in the female. This graft has the distinct advantages of not becoming as discolored as the full thickness graft, retaining its elasticity, being resistant to trauma, and approaching the normal surrounding skin in appearance. These grafts may be placed anywhere on the body and are frequently used to cover defects of exposed surfaces of the face and hands. They take best on denuded surfaces or those surfaces from which the granulating tissue has been removed down to a fine scar base. Great care has to be exercised in the elimination of infection, and hemostasis should be absolute before application of the graft is carried out.

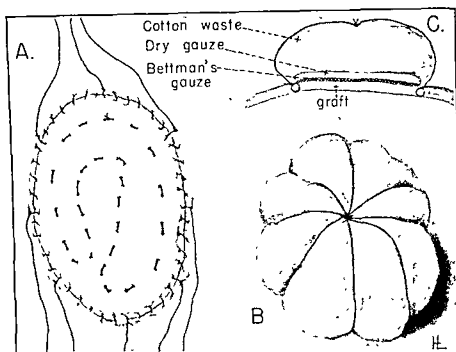


Fig. 161.—*A*, The graft is placed on the recipient site and the edges are united to the adjacent skin with interrupted and continuous sutures of silk. The center part of the graft is sutured to the underlying surface with a basting suture of silk. *B* and *C*, The graft is covered with a layer of Bettman's gauze, over which is placed cotton waste. The long ends of the interrupted sutures are tied across to assure pressure and immobilization of the graft

The removal of these grafts is the same as that described above for the epidermal grafts, and they may be taken with a free knife or with a dermatome. Immobilization of these grafts is a necessity to insure successful "takes," and they should be cut to the pattern of the defect they are to cover. The skin edges and graft should be united with interrupted and continuous four 0 or five 0 silk (Fig. 161, *A*). Firm pressure is made over the entire grafted area to remove from under the graft air bubbles or pockets of blood and serum. When large areas are covered, the graft should be sewed to the underlying bed with interrupted or continuous basting stitches to assure further immobilization. The surface is covered with fine mesh or scarlet red gauze and pressure bandages are applied.

There are several methods of assuring pressure. The best is by the use of cotton waste placed over the entire graft and extending on to the adjacent skin areas. This waste is then held against the site by external adhesive and elastic bandages. Sea sponges or rubber sponges may be used in place of waste if so

desired. One simple technic of assuring immobilization, and at the same time securing pressure, is to leave the ends of the interrupted sutures between the skin and graft long and to tie them across the gauze waste placed over the graft. This procedure is particularly useful where external bandaging will prove impractical or difficult (Fig. 161, *B* and *C*).

There have been various technics of plasma fixation of grafts devised. The method described by Sano, in which heparinized plasma is applied to the recipient area and a white cell extract in Tyrode's solution is applied to the undersurface of the graft, received favor for a time. These technics have been used by us repeatedly without offering any advantage over those of external fixation described above. In addition there was definitely a higher percentage of "non-takes" unless *other fixation procedures were used at the same time.*

Bandages upon intermediate grafts should not be disturbed until at least the seventh day, at which time the grafts are dressed and cleansed gently with 50 per cent hydrogen peroxide solution. If healing is progressing satisfactorily, one-half of the sutures are removed, including those in the center of the graft. The remainder are left in until the tenth to fourteenth day. Any area of definite sloughing should be removed by sharp dissection, care being taken to produce a minimal amount of bleeding. Pressure dressings are reapplied and are changed every other day until healing is complete. After a period of six weeks, the graft should be massaged with cocoa butter to lessen the amount of rigidity and also to stimulate the circulation. This therapy should be given for fifteen minutes every day for the next eight weeks.

Dermal Grafts

Dermal grafts are the split skin grafts which do not include any epidermal surface. These should be obtained from non-hair-bearing areas and are used as buried grafts to substitute for the loss of subcutaneous tissue and occasionally for supportive cartilage and bone about the face. The prerequisites for their use is that the area into which the transplant is to be placed is free of infection and absolutely dry. Needless to say, the blood supply of the surrounding tissue should be adequate to permit healing of the tissue transplant.

Technic for Removing Dermal Grafts.—The procedure of choice in taking dermal grafts is by the use of the dermatome. With this instrument the epidermis is removed from the donor site and then in turn taken from the drum and saved. The rest of the thickness of the skin on the donor site is removed in the same way as a full thickness graft, that is, the edge of the graft is caught with hooks and elevated, and with a sharp knife the undersurface of skin is dissected from the subcutaneous tissue. The entire graft is thus removed and the raw surface of the donor site is covered with the epidermis which has been saved. If the graft is large, the epidermis may be sutured to the surrounding edge of the skin with interrupted and continuous four 0 or six 0 silk sutures. The site is then covered with scarlet red gauze and dressed with pressure bandages and gauze waste. The dermis is ready for transplantation.

Dermal grafts are used in small depressions occurring in the subcutaneous tissue of the face rather than transplanted fatty tissue. They are used to fill out slight depressions of the dorsum of the nose and also depressions of the upper lid

following removal of the globe. The skin over the area is dissected free of the underlying subcutaneous tissue. The dermal graft may be placed in layers or folded to conform with the shape of the depressed area. The incision is closed with fine silk sutures and a moderately firm pressure is applied over the grafted area for a total of ten days. Following implantation of such grafts, the entire area will be indurated for varying periods of time, usually three weeks. One must be on the alert for fluctuation, as this denotes an accumulation of either serum, blood, or pus A diagnostic aspiration, using a small needle, should be made. If pus is present, the graft should be removed; if serum or blood is present, repeated aspirations are necessary to assure healing of the underlying graft.

FULL THICKNESS GRAFTS

Full thickness grafts consist of the entire full thickness of skin devoid of all subcutaneous tissue. Physical properties of this skin following a succesful "take" are the same as that of normal skin. If hair follicles are included in the graft, the hair will grow just as before it was transplanted; therefore, if a full thickness graft is used to cover areas in which the hair is normally not present, a suitable site devoid of hair should be chosen for the donor area. Conversely, this property is of definite advantage in the transplantation of the full thickness scalp graft for the formation of eyebrows. One great disadvantage of full thickness graft is that frequently when skin is taken from an unexposed portion of the body and transferred to that of the hands and face where exposure is constant, the entire graft may be subject to an increased deposit of pigment, brownish in color, which may prove unsightly. Because of the thickness of the graft, the demand for early blood supply is greater, and a successful 100 per cent "take" is not as frequent as that of the split thickness graft. Often at the first dressing one finds desquamation of the epithelium of the entire graft which is attributed to the failure of early vascularization with superficial epithelial loss. This does not mean that the entire graft will not live as regeneration of an epithelial covering will occur. Full thickness grafts will not take on granulating surfaces and should granulation or excessive scar tissue cover the recipient area, it is necessary that all of it be removed down to a normal healthy bed of soft tissue before the graft is applied. Absolute success can never be obtained where infection is present. Because complete vascularization is necessary, a longer period of immobilization is required. There is always danger of degeneration of the skin from too early dressings and other trauma which may damage the blood supply.

The method of obtaining a full thickness graft is quite simple. (Fig. 162.) Following the removal of all granulating and scar tissue from the recipient area, a pattern is made, outlining the contour of the defect. The material for this may be rubber tissue, paper, paraffin gauze, or metal foil. The pattern is placed over the donor site and the skin around it is outlined with a sharp-pointed knife. The full thickness of the skin is incised and its edges are picked up by small forceps or hooks and rotated upward so as to expose the underlying surface. Using a sharp knife, all of the subcutaneous tissue is removed and the complete graft is dissected out.

The graft is placed into its correct position in the recipient site and its surrounding edges are sutured to the adjacent skin with interrupted and continuous four 0 and six 0 silk. Here as in thick split thickness grafts, immobilization may be

obtained by using a basting or interrupted suture in the center of the graft if external immobilization cannot be adequately applied. Caution should be used against the collection of serum, blood, and air beneath the graft and these should be expressed before the dressing is applied

The bandages should be left on the graft for seven to ten days and following their removal all desquamation should be cleared away. If healing has taken place, one-half of the sutures may be removed and the remainder left in from ten to fourteen days. Pressure bandages should always be used for a period of fourteen to twenty days, depending entirely upon the progress of the healing of the wound. The donor site can be closed usually by undermining the skin edges and suturing these together with silk sutures Occasionally, where large areas of full thickness skin have been removed, the donor area may be covered with split thickness grafts removed from another site.

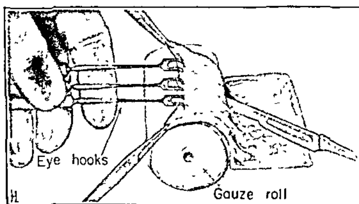


Fig. 162.—An outline of the area of skin to be removed is incised. The edges are dissected up with a sharp knife and caught with clamps or hooks and carried backward over a small roll of gauze as the dissection progresses.

Small Full Thickness Grafts

Small full thickness or Davis grafts are used on large granulating areas in which the granulations are no higher than that of the surrounding skin and are healthy in appearance. These should never be placed upon exuberant granulating tissue. The only advantage of this graft over the small split thickness graft is that there is less subsequent contraction of the grafted area and the wound is more resistant to trauma. The percentage of "takes" is never as high as that of the small split thickness graft. Firm pressure fixation should be used for at least four to seven days.

The method of obtaining these grafts is by inserting a straight sewing needle into the full thickness of the skin, drawing it upward, and amputating the base of the cone (Figs 159 and 160). This will enable the operator to obtain a small circular area of full thickness of skin. The donor site is covered with scarlet red or fine mesh gauze over which gauze dressings are applied and left for two weeks before dressing. At the end of this time complete healing has usually taken place. The aftercare of the grafted site is the same as that described for the small split thickness grafts.

Sieve Grafts

In 1930 Douglas described the technic and application of the sieve graft. This consists of a full thickness graft that has circular punched-out areas throughout,

measuring approximately 3 to 4 mm. in diameter. These areas are left intact at the donor site to act as nuclei about which epithelization will take place. The technic for obtaining these grafts is the same as that for the full thickness, except after the pattern has been outlined on the normal skin these small circular areas are cut through the graft using a circular die (Fig. 163). In dissecting the full thickness of the skin upward, the small circular areas of skin are left intact. The application of the sieve graft to the recipient site is the same as that of the full thickness graft. It offers, however, no real advantage over that of the normal full thickness graft as a covering and is not practical for the best cosmetic appearance since the small circular areas have to heal by epithelization, producing an unsightly mottling. It does have an advantage in that the islets are left intact on the donor site, thus eliminating the problem of closing the wound (Figs. 164 and 165).

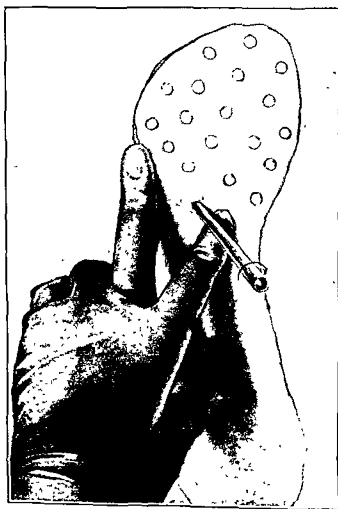


Fig 163.—Steel die boring out islands of skin at equal distances from each other throughout the outlined donor site of the graft. The surrounding skin is held at tension with the fingers. (Horsley, John S, Jr.: Internat S Digest 16: 67-82, 1933.)

TUNNEL GRAFTS

Tunnel grafts are embedded beneath the skin, scar, or open wound and may be either full thickness or split thickness grafts of skin. They are indicated most frequently in areas which have excessive amounts of scar tissue and are chronically infected Free grafts used on these surfaces would have a relatively small chance of taking unless they were thin. The tunnel or cavity is prepared as follows, be-